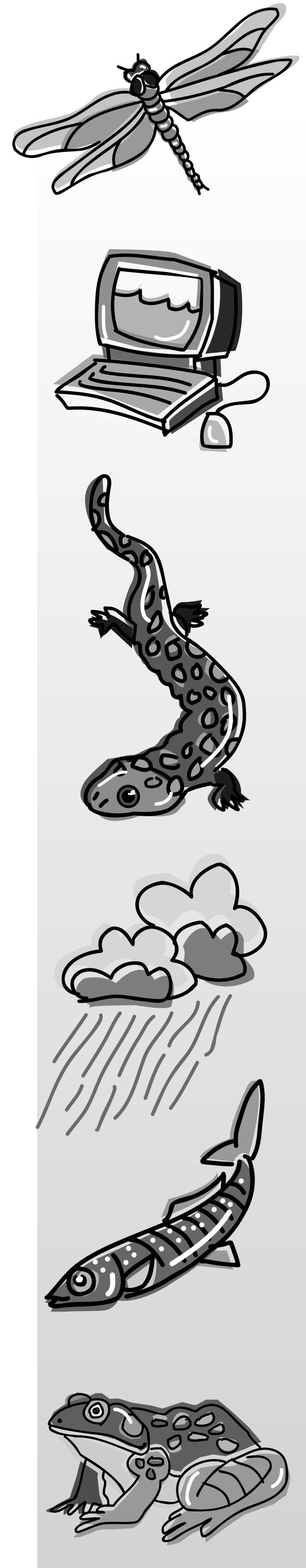
WatershED

Boulder Creek/ St. Vrain Watershed Education



TEACHERS' RESOURCE GUIDE

TABLE OF CONTENTS

BOULDER CREEK/ST. VRAIN WATERSHED EDUCATION

Appendices

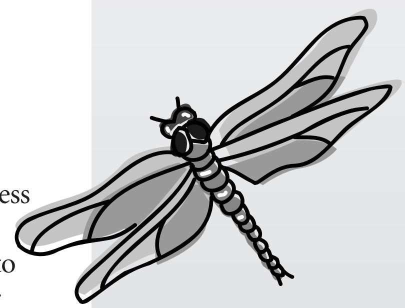
WatershED*: your guide to finding out about the place you live*

WatershED*: your guide to becoming a steward of your water resources*

WatershED*: your guide to local participation and action*

THIS GUIDE WILL HELP YOU . . . .

- get to know your Watershed Address—where you live as defined by creeks, wetlands and lakes
- discover the plants, animals, and birds you might see in or around the creek or wetland in your neighborhood
- organize a StreamTeam to protect and enhance a nearby waterway



WatershED is a resource guide for teachers and students. It provides you with the information needed to learn more about the creek or wetland near your school. It gives suggestions for what your class can do to preserve and protect that waterway.

WatershED is an Earth systems science approach to learning about interconnectedness of the water, ecology, geology, meteorology, human influence, and other physical and chemical interactions in our local Boulder County region. Teachers are encouraged to take an interdisciplinary "team teaching" approach when they are teaching about our local environment using the activities contained in this curriculum guide. Because of the interdisciplinary nature of this curriculum, listed below are brief summaries of how other content areas of the Colorado Model Content Standards are applied in this curriculum. Colorado Model Content Standards for science are provided at the beginning of each activity.

Geography: Students will use and construct maps to locate and derive information about their local watershed. Students will gain a sense of place with respect to human, physical, and natural characteristics. Students will observe patterns and change of physical processes that shape the Earth.

Mathematics: Students will use data collection and analysis to understand various interactions within their local watershed. Students will analyze stream flows, biological measurements, water use, water quality, and population interactions.

Reading, Writing, and Languages: Students will journal, create informational storm drain marking flyers, and conduct research on their local watershed. All activities may be taught with additional reading and writing components that may include community presentations, production of newsletters, etc. All activities may be taught in foreign languages and evaluate watersheds in other countries as an extension to these activities.

History: Students will understand how science, technology, and economic activities affect local watershed history.

Civics: Students will understand the purpose for local government interaction and the role of citizen participation in watershed protection.

Economics: Students will understand the condition of scarcity when evaluating drought conditions and the need for water conservation practices. Students will understand the economic aspects of using natural resources.

Visual Arts: Students will build watershed models, make flyers, and draw observations of their local watershed.

ACKNOWLEDGMENTS

This watershed resource guide was made possible by grants from the Denver Urban Resources Partnership Office and the Bureau of Reclamation. The primary authors on the guide were City of Boulder WASH Education Outreach Coordinator, Tammi Laninga, and Boulder Creek Watershed Initiative President, Jeff Writer. We would like to thank the Boulder Valley School District teachers who reviewed the guide and piloted many of the activities: Holly Cunningham, Whittier Elementary; Emily Weller, Bear Creek Elementary; Nadyne Orloff, Halcyon School; Dan Tomlin, Burbank Middle School; and Jeff Writer, Centaurus High School.

2004 revisions provided by WASH Education staff.

WASH

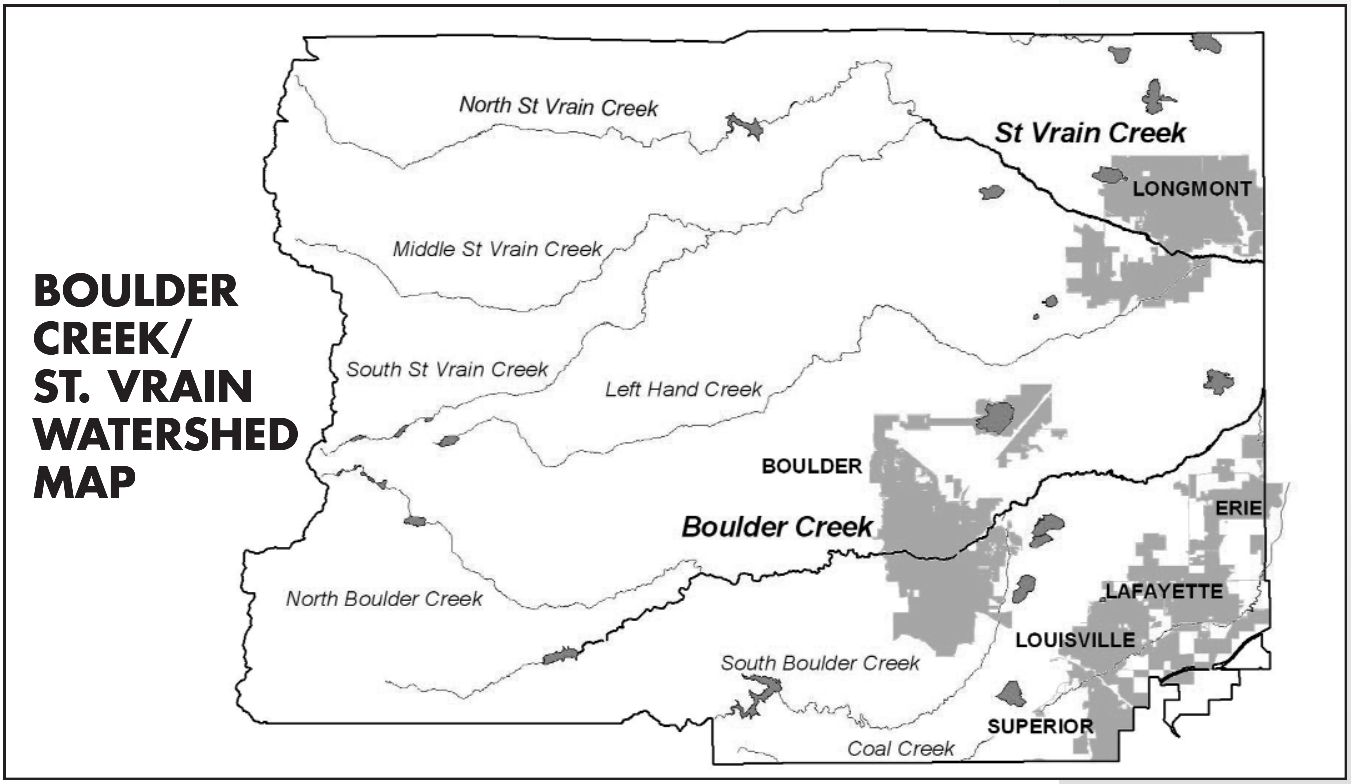
A partnership of communities in the Boulder and Saint Vrain watersheds working together to protect our water quality.

BOULDER COUNTY • CITY OF BOULDER • CITY OF LONGMONT
CITY OF LOUISVILLE • TOWN OF ERIE • TOWN OF SUPERIOR

THE BOULDER CREEK/ST. VRAIN WATERSHEDS

Everyone lives or a watershed, and most of us live near a river or stream. We live in the Boulder Creek St. Vrain Watersheds. Learning about our watershed will give us the necessary tools needed to ensure the protection of this incredible water resource.

A watershed is an area of land that drains into a stream or lake. Watersheds range in size from an area drained by a small alpine spring to a large river system such as the Mississippi, which drains the entire central portion of the United States.



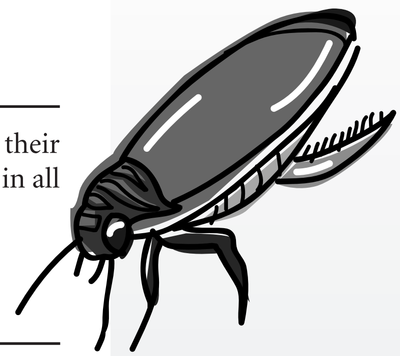
Boulder County lies within the St. Vrain watershed, which is part of the larger South Platte River Basin, which is nested within the Missouri/Mississippi River basins. The basin is bordered on the west by the Continental Divide between Longs Peak and James Peak. The headwater tributaries provide a significant portion of the drinking water supply for those living in the basin. Boulder County accounts for 75% of the 993 square-mile area, with the remainder extending into portions of Gilpin, Jefferson, Adams and Weld counties. The 440-square-mile Boulder Creek/St. Vrain watershed is the major "sub" basin within the St. Vrain watershed. The basin is a complex natural system which has specific needs to remain in balance.

The watershed supports trout in the higher stream reaches and warm water fish such as bass and sunfish in the lower reaches. An abundant number of aquatic insects and water fowl can also be found in and around the many creeks of the watershed. Boulder Creek and it many tributaries also provide a number of valued uses for the community such as water for irrigation and drinking, recreation, flood control, and hydropower.

The cities of Nederland, Boulder, Louisville, Lafayette and Superior are the largest cities in the watershed. According to the 2000 census, over 291,000 people were living in Boulder County. That number is expected to increase 15% to bring the total population to 335,000 by 2010. As population in the basin grows, development and the associated water quality impacts will also increase.

Human impacts to the Boulder Creek/St. Vrain Watersheds are many and varied. Historical mining activity in the upper reaches of these watershed introduced metal contaminants into creeks. More recent impacts to our waterways include building reservoirs for water supply and hydropower; straightening and channeling steams for flood protection; developing towns and cities along the primary waterways; and taking water for irrigated agriculture. The combined results of these uses have been the reduction of stream side vegetation; degradation of water quality from agriculture and urban pollution; loss of native aquatic species; and a general degradation of aquatic and riparian ecosystems.

The job of preserving our larger rivers, reservoirs and aquifers is a task for local, state, and national organizations. By protecting our smaller streams and restoring local watersheds we can each be a part of the solution. Since every one of use lives in a watershed, each of us directly affects the health of a nearby creek. Everyone can help restore, protect or enhance a stream at the local level. By monitoring streams that flow by our schools and homes, we can get an idea of the activities going on in the watershed upland from us. And we can make sure that we ourselves are not degrading water for the people who live downstream. You can do this by organizing a StreamTeam in your classroom. Your StreamTeam can adopt a stream to protect and enhance. The best way to learn about the creek near your school is to jump in!



WHAT IS ECOLOGY?

Ecology is the scientific study of how living things interact with each other and their environment. Ecological interactions take place and can be studied scientifically in all environments, including cities and suburbs.

ECOLOGICAL CONCEPTS

Interdependence of living and nonliving "elements": Interdependence means that each element is somewhat, if not totally dependent on the other for its ability to function.

Ecosystems: Ecosystems are groups of living and nonliving things that function together in a particular environment. For example, prairie dogs, birds, insects, low-lying grasses, and shrubs (living elements) interact with each other as well as with dry soil, high winds, and occasional downpours (nonliving elements) to make up the shortgrass prairie ecosystem.

Community: All the organisms that live together in an ecosystem comprise a community. In the above example, prairie dogs, birds, insects, grasses, and shrubs make up the shortgrass prairie community.

Habitat: Good habitat has four essential components—food, water, shelter, and space. Each species has different requirements for the types and amounts of each habitat component. Five common urban habitats include: the urban edge, the inner city, the backyard, the riparian corridor, and the park and open space. In the Front Range, there are countless habitat types and more than 350 common species of wildlife that exist in this area.

Source: Moorhead, Carol Ann. Colorado Backyard Wildlife. Roberts Rhinehart Publishers 1992. pages 25-32.

WHAT IS AN ECOSYSTEM?

Ecosystems encompass all the parts of a certain environment, including the living (biotic) plants and animals, and the nonliving (abiotic) components, such as soil, water, air, and the sun's energy. Ecosystems transition into another one with little change or distinction; for example, it is hard to tell exactly where a stream turns into a river.

Every ecosystem contains species of plants and animals. Each species occupies its own ecological niche or role that it fulfills in the environment. Ecosystems found in the Boulder Creek/St. Vrain Watershed include plains grasslands, mountain grassland and meadows, lowland riparian, mountain riparian, ponderosa pine forest, aspen groves, lodgepole pine forests, alpine tundra and the aquatic ecosystem. The focus of this section will be the lowland and mountain riparian zones and the aquatic ecosystem.

Species of Lowland Riparian Ecosystems

(refer to appendix for full listing of species)

Trees

green ash, plains cottonwood, peach-leaved willow

Shrubs

hawthorn, wild rose, wild plum, sandbar willow

Herbaceous Plants

broad-leaved cat-tail, poison ivy, saltgrass, sunflowers, bulrush

Birds

geese, ducks, grebes, herons, egrets, gulls, owls, hawks, dippers, warblers, flycatchers, jays, wrens, woodpeckers, belted kingfisher

Reptiles & Amphibians

tiger salamander, woodhouse's toad, western chorus toad, bullfrog, snapping turtle, short-horned lizard, western rattlesnake, smooth green snake, northern water snake, bullsnake, common garter

LOWLAND RIPARIAN ECOSYSTEMS

Lowland riparian ecosystems are found along banks of rivers, streams and other bodies of water and include floodplain woodlands and marshes. They are narrow, transitional zones between aquatic and terrestrial ecosystems with distinct vegetation and soils. Before the development of Boulder County, the only deciduous trees in the Boulder Creek/St. Vrain Watersheds where found in the riparian ecosystem.

Trees and other vegetation help to moderate intense winds and sunlight in this ecosystem. Often soils are young and moist, with a high water table and poor drainage due to continuous changes in water flow (drought or flood) or erosion.

Lowland river bottoms and marshes are the most productive natural ecosystems in the region—for plants and wildlife. Many animals live in or near the riparian zone because of the lush forage, water, and abundant denning or nesting sites. Riparian zones also offer a refuge to animals that live in other ecosystems. Many bird, reptiles, amphibians and small mammals make their homes in the riparian ecosystem.

Humans have used and affected the lowland riparian and wetland ecosystems. Impacts to these ecosystems include mining gravel along stream banks, cutting cottonwoods for firewood and lumber, building housing developments in the flood plain, grazing cattle, and artificially channeling and damming waterways for flood protection and water supplies.

MOUNTAIN RIPARIAN ECOSYSTEMS

Mountain riparian ecosystems are found adjacent to streams, ponds and lakes. Small meadows dominated by deciduous trees and moisture-loving shrubs form this ecosystem. High mountain streambanks and wetlands support a diverse array of plant communities that provide food and cover for many animal species.

Mountain riparian ecosystems are found throughout forested mountains (5600 to 11,000 feet). Since streams run through the mountains at all altitudes, riparian ecosystems form continuous strands that cross the subalpine and montane forests. At their upper edges the ecosystems pass through tundra marshes; they merge with lowland riparian ecosystems at their lower limits.

Riparian ecosystems in mountain and subalpine regions have fewer species than at lower elevations, but diversity is still high compared to most adjacent ecosystems. They provide abundant food and cover for a variety of birds and animals.

Mountain riparian ecosystems have been greatly altered by human use. Some of the impacts in this ecosystem include removal of beavers to create hay meadows and cattle grazing, building transportation routes adjacent to streams, mining peat bogs, housing developments, and mining of minerals found in the mountains. Many aquatic reaches have been stained yellow or orange with mineral deposits and are devoid of insects and fish. This activity has not directly impacted the mountain riparian ecosystem but has also impacted ecosystems downstream.

AQUATIC ECOSYSTEM

Aquatic ecosystems are streams, rivers, ponds, lakes and reservoirs. In these ecosystems, the distribution of organisms is determined by water temperature, clarity, current, the amount and kind of dissolved materials, and the types of materials that line the stream or lake bottom.

Characteristics of streams, and thus plant and animal habitats, change with elevation as the streams flow from the mountains to lower elevations. At the highest reaches, the water is cold and almost as pure as distilled water; stream beds are steep and strewn with boulders; and dissolved oxygen levels are high because of the cascading water and cold temperatures. Few aquatic plants can survive the cold, swift moving, nutrient-poor waters of the highest streams. In these places the major energy source is organic detritus (leaves, twigs) which serve as food for microbes, aquatic insects and other small organisms.

At middle elevations, stream channels are not as steep and the stream bed has both boulders and rocks. Mid-elevation streams alternate between deep, quiet pools and riffles: shallower areas with a steeper slope, faster current, and a bed of large, cobble-sized rocks. Pools and riffles each provide a unique habitat to stream inhabitants. At middle elevations, where currents lessen and more phosphorous, nitrogen and other plant nutrient are available in the water, a coating of periphyton covers the stream bed rocks. This living film is an important food source for insects and other invertebrates. It consists of algae, diatoms, and water moss. Riffles are particularly productive areas, where periphyton-covered rocks support a diverse insect community. Pools accumulate detritus and are important sites for organic decomposition and nutrient recycling. Riffles are important feeding grounds for trout, while pools provide quieter water for them to rest.

At lower elevations, where streams leave the mountains, the gradient declines and currents slow down causing concentrations of dissolved salts to increase, temperatures to increase, and oxygen content to decrease. Accumulations of suspended particulates reduce the water's clarity. At times, streams are extremely turbid, especially during spring runoff. The sediments of low elevation stream beds are more fine-grained than in the mountains, and consist of gravel, sand or silt.

Healthy riparian ecosystems are of prime importance to aquatic habitats. Riparian vegetation helps hold stream bank soils in place, which in turn reduces the sediment loads entering them. Riparian lands also contribute organic detritus to streams, which often serves as the most important source of energy for aquatic food webs.

Streams and rivers are inhabited by a variety of aquatic organisms. The largest organisms are vertebrate animals—fish and a few amphibians and reptiles. The invertebrates—insects, snails, flatworms, leeches, and other small animals without backbones—are far more numerous. There are two types of invertebrates: macroinvertebrates are those that can be seen without a microscope; and microinvertebrates are those you can see only under a microscope.

Stoneflies, mayflies, caddisflies, true flies, and riffle beetles collectively comprise about ninety percent of the total macroinvertebrate fauna of the Boulder Creek/St. Vrain Watersheds stream systems. The most abundant fish found in the higher, cooler

Species of the Mountain Riparian Ecosystem

(refer to appendix for full listing of species)

Trees

alder, cottonwood, birch, Colorado blue spruce, white fir.

Birds

Yellow warblers, American goldfinches, will and cordilleran fly-catchers, western woodpewees, belted kingfishers, hawks, owls, green-winged teal, mallards, dipper

Reptiles & Amphibians

tiger salamander, boreal toad, wood frog, striped chorus frog, smooth green snake

Mammals

water shrew, muskrat, montane vole, western jumping mouse, chipmunks, squirrels, rabbits, beaver, moose, river otter

1 Activity Level

streams of this area include brook, rainbow and brown trout. These species were introduced into area streams more than 100 years ago. These exotic fish species have reduced the population of the native cutthroat trout and restricted its populations to the highest and steepest streams. In the warm water streams of Boulder County, channel catfish, suckers and sunfish are abundant.

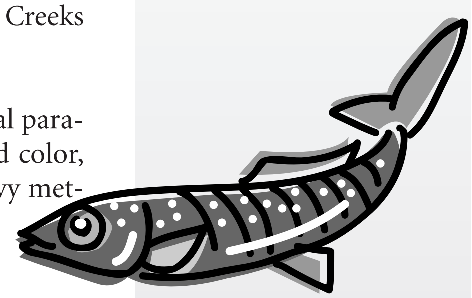
Aquatic ecosystems are impacted by a broad range of human activities. The ecosystem has been affected by the following actions: heavy metal pollution from acid mine drainage; dust and oil from roads; pesticides, fertilizers, animal waste from agriculture; industrial wastes; heated water from power plant condensers; and treated and untreated discharges from municipal sewage treatment plants; damming rivers or building transbasin water diversions for drinking water supply and irrigation; and introducing non-native fish species for sport fishing.

Human modifications have reduced the number of destructive floods, increased the number of fish species, and provided water to relatively dry places. However, in return we have decreased the number of free-flowing streams and health aquatic ecosystems to the point that they have become as endangered as the rare species within them.

Source: Mutel, Cornelia Fleischer and John C. Emerick. *From Grassland to Glacier: the Natural History of Colorado and the Surrounding Region.* Johnson Publishing 1992. pages 59-70; 71-85; 205- 226.

Boulder Creek and St. Vrain Rivers begin in the Rocky Mountains west of the foothills. Those creeks flow through the mountains and canyons toward Boulder County communities, picks up pollution particulates from the air, travels past old mines, and through some agricultural and residential areas. When these streams reach Boulder and Longmont, the y flow through the middle of town. Here they are subject to the strains of the city: automobile oil, paint, fertilizers, treated wastewater effluent, food wastes, trash, etc. The creeks eventually meander into eastern Boulder County where they traverses farms and new rural subdivisions. On their journey from the high mountains to their convergence with the St. Vrain River, Boulder and St. Vrain Creeks are influenced by every type of urban and rural impact.

The health of a stream can be monitored with physical, chemical and biological parameters. The primary physical and chemical parameters include turbidity and color, temperature, flow, dissolved oxygen, pH, and chemical pollutants such as heavy metals, nitrate, and phosphate.



COLOR AND CLARITY

We can learn a lot about a stream by its color and clarity. Rainwater, groundwater and snowmelt run clear unless a stream's banks are eroding. Glacial meltwater, on the other hand, appears milky gray from "glacial flour," tiny suspended particles of rock crushed by the grinding force of moving glaciers. Brown water might be a sign of a mudslide in the mountains, a heavy storm event, or local erosion. Greenish water may represent blooms of algae nourished by excess fertilizers from yards, golf courses, or farms. "Suds" might point to detergents or to septic tank failure. An iridescent sheen on the water may have been released from rotting leaves; however it could mean that used motor oil or oil-based pesticides leaked or were dumped into the stream, or perhaps it was picked up in runoff from roads, driveways, and parking lots. To test the clarity of a creek, turbidity measures are taken. Turbidity is defined as the light scattering capability of a particle. In natural waters, it may be caused by algae or by organic acids, which stain the water a dark brown. But it usually indicates suspended sediments—fine soil particles, held in suspension by the turbulence of the current—which scatter light passing through the water. Excess sediment reduces the clarity of water and it can harm the gills of fish and aquatic insects. It also makes it more difficult for aquatic species to find food and escape predators.

TEMPERATURE

Water temperature is another easy test that tells a lot about a waterway. Temperature determines where aquatic organisms can live. Plants and animals that live in the creek are completely surrounded by water, and so their "climate" depends on water temperature rather than air temperature. In fact, since fish and aquatic insects are "cold-blooded," they become the temperature of the water. Their metabolism, growth rate, and all internal chemical reactions are regulated by the water temperature. The amount of oxygen found in a waterway is directly connected to the temperature. Cooler water holds more dissolved oxygen than warmer water. Different aquatic species have found their habitat in streams according to food availability, oxygen needs and temperature. Trout like cold, oxygen-rich waters, whereas bass and sunfish prefer to live in warmer water.

CURRENT AND FLOW

Current and flow are also easy characteristics to monitor. Activity 3.4 provides directions for taking flow on your waterway. Current is determined in part by the gradient, or slope, of the stream. Mountainous headwaters have swift currents because they drop quickly over a short reach. Current also varies with the flow, which is the amount of water carried by the stream channel at any given time. Water levels fluctuate throughout the year. During the spring, the creeks in the Front Range rise quickly and have swift currents because of melting snow in the mountains. By midsummer, when most of the snow has melted and the hot, dry weather sets in, creeks slow down and sometime even dry up. Creeks may rise for a short time during the summer if a heavy thunderstorm releases a lot of rain over the headwaters of a creek. During fall and winter, watershed creeks maintain a fairly slow, constant flow, as rain and snow contribute more consistent water to the creeks. During normal flow, currents are controlled by instream structures, both natural and human-made. Large boulders, fallen trees, and beaver dams are examples of natural current checks. On a larger scale, hydroelectric, irrigation and flood-control dams also check the current. Knowing the flow and current of a stream helps us know how quickly something, such as a pollutant, might travel down a creek. We can also determine the types of animals that live in the creek depending on the site.

DISSOLVED OXYGEN (D.O.)

Some important stream measurements are not as visible as the first ones mentioned. There are certain things that need to be measured with sampling equipment, such as the levels of dissolved oxygen in a stream.

Instream creatures depend on oxygen that is dissolved in the stream water. Still or slow-moving water gets some oxygen from the air above it. In a pond, for example, only the upper layers receive much dissolved oxygen, while the bottom layers are often depleted by the respiration of animals in the mud and by bacteria decomposition.

Rushing water, as it churns over rocks and plunges over hundreds of tiny falls, is aerated by the bubbles of air that get caught by the water. Plants add oxygen to the water during daylight as a byproduct of photosynthesis, but they also deplete it as they respire a night. Water never contains large amounts of oxygen: our atmosphere contains 23% oxygen, whereas even oxygen-saturated water has less than 1%. Small losses or gains in D.O. levels can be critical to instream species.

The amount of D.O. in a stream is dependent on three things: water temperature, the amount of oxygen taken out of the water by respiring and decaying organisms, and the amount put back by physical aeration and photosynthesis. The cooler the water is, the more dissolved oxygen it can hold. Large active fish like trout, which need a lot of oxygen, are restricted to cool streams.

pH

pH is another invisible, yet very important parameter to measure. pH is the amount of hydrogen ions in the water (p stands for "negative logarithm of"; H for hydrogen ions). The lower the number, the higher the acidity. The pH scale goes from 1-14. pH

7 is neutral (distilled water); pH 2 is acidic (vinegar); pH 13 is basic (ammonia). pH affects the solubility of many nutritive and toxic chemicals in the water and thus their availability to stream creatures. Alkalinity—the opposite of acidity—is a measure or the stream's capacity to buffer, or neutralize, the effects of acidity.

CHEMICAL POLLUTANTS

A final test to measure a stream's health is to monitor for chemical and heavy metal pollutants. Some pollutants, not soluble in water, can be easily detected. Petroleum products spread over the surface of water creating a rainbow sheen. Other chemicals may have volatile gasses that can be detected by smell. And some, like detergents, give a slippery feeling to the water or create suds on the surface. Unfortunately, most chemicals dissolve in water and cannot be detected except by expensive laboratory instruments. The only way we "see" them is by noting their effects on stream life—organisms sensitive to chemicals may die out while more tolerant ones thrive.

Major chemical spills will cause dramatic plant and animal deaths throughout the impacted stream. However, most waterways are slowly degraded over a period of months or years. Certain chemicals and metals are tested regularly because of their effects on the aquatic ecosystem and their potential danger to humans. Lead is tested in our drinking water because its compounds are poisonous and accumulate in the bone structure. Lead is seldom found in surface waters because it is precipitated by a variety of substances. Nitrate and phosphate are two chemicals tested for because they are nutrients. High levels of nitrates and phosphates can lead to the excessive growth of aquatic plants. High levels in natural water supplies may indicate some nonpoint source pollution problems such as fertilizer runoff from lawn or fields.

One other constituent often tested for is the fecal coliform bacteria. It is important to find out if our water sources are being polluted by septic tank or agricultural runoff. If fecal coliform is detected in a waterway, it means that certain disease causing pathogens are present. These pathogens can cause great harm to both aquatic species and humans.

STREAM INSECTS

Benthic (creekbottom) macroinvertebrates, or stream insects are an important feature of the stream ecosystem. Stream insects are monitored to check the overall health of the stream. This bioassessment is conducted for a number of reasons:

1) macroinvertebrate communities have limited migration patterns, thus they are good indicators of localized conditions;

2) they integrate the effects of different pollutants and other short-term environmental variations, thus providing a holistic measure of the impact of various contaminants; and

3) as a primary food source, they are important to the overall health of the stream ecosystem.

As you can see, the creek ecosystem is dependent on many things working together to maintain a healthy balance —clarity, temperature, current and flow, dissolved oxygen, pH and chemicals. To make sure our waterways are protected, these parameters should be monitored regularly.

Source: Yates, Steve. Adopting a Stream: A Northwest Handbook. Published by The Adopt-A- Stream Foundation. 1988.

BACKGROUND

Stormwater runoff occurs when precipitation from rain or snowmelt flows over the ground. Impervious surfaces like driveways, sidewalks, and streets prevent stormwater from naturally soaking into the ground. Stormwater can pick up debris, chemicals, dirt and other pollutants. These pollutants then flow into a storm sewer system or directly to a lake, stream, river or wetland. Anything entering a storm sewer system is discharged untreated into the waterbodies we use for swimming, fishing, agricultural uses, and providing drinking water.

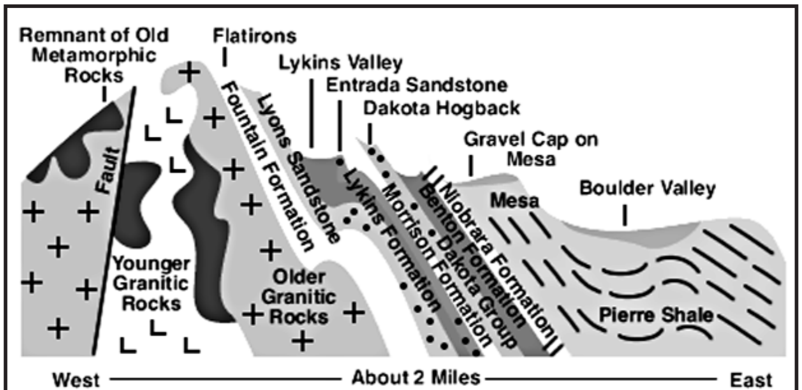
The effects of stormwater pollution include:

- Sediment can cloud the water and make it difficult or impossible for aquatic plants to grow.
- Excess nutrients can cause algae blooms. When algae die, they sink to the bottom and decompose in a process that removes oxygen from the water. Fish and other organisms can't exist in water with low dissolved oxygen levels.
- Bacteria and other pathogens can wash into swimming areas and create health hazards.
- Debris, trash and yard waste washed into waterbodies can cause flooding and can dump debris on neighboring yards.
- Household Hazardous wastes such as pesticides, paint, solvents, used motor oil, and other auto fluids can poison aquatic life. Land animals and people can become sick or die from eating diseased fish and shellfish or ingesting polluted water.
- Polluted stormwater often affects drinking water sources. This, in turn, can affect human health and increase drinking water treatment costs.

Information above from WASH After the Storm brochure. Majority of text provided by the EPA. 2003

BRIEF SUMMARY OF BOULDER GEOLOGY

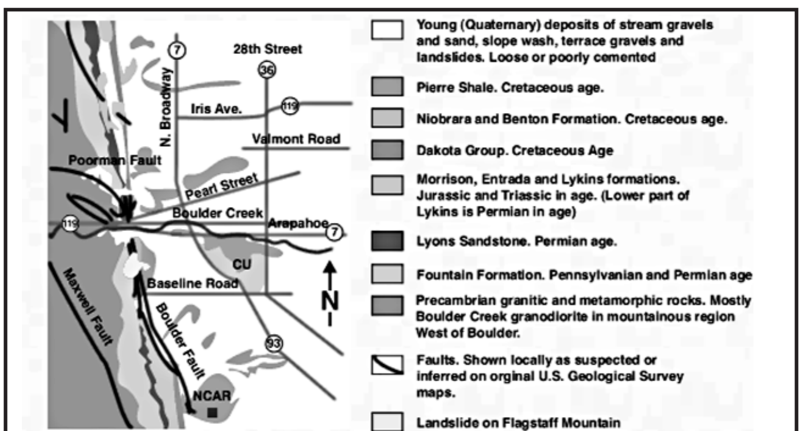
Two great geologic provinces come together in the Boulder County region. The eastern province is the Great Plains, ranging from rolling hills to flatlands, and the western province is the Rocky Mountains. The north-south front where the two meet is called the Front Range.



Generalized Cross-Section East-West Across the Boulder Area

The thicknesses are not to scale. adapted from Runnells (1976) by e.keefe

About 135 million years ago, sands and gravels were carried eastward over the Boulder County region from mountains rising to the west in Utah and Nevada. At about the same time, a massive invasion by the sea began in eastern Colorado. The sea entered the central U.S. from the north and south, laying down a deposit of beach sand along its edge. The next 70 million years were marked by several advances and retreats of the sea. The deposits associated with these episodes of marine flooding consist of shale, sandstone, limestone, and some beds of coal.



Simplified Geologic Map of the Boulder Region

adapted from Runnells (1976) by e.keefe

About 70 million years ago, the sea slowly withdrew to the northeast, and mountain building began again in Colorado, forming the present Rockies. As the mountains were uplifted, swiftly flowing streams carried floods of debris downward to the plains. Hot magma invaded the older rocks of the mountains, and the forces of mountain building caused the rocks to be greatly deformed. Active mountain building continued throughout the remainder of Tertiary and Quaternary time. During the past million years or so, there were many active glaciers in the mountains west of Boulder. Glacial deposits and erosional features can be seen in the mountains west of Boulder.

For more detailed geologic history, see the Geologic History of the Boulder Area : http://bcn.boulder.co.us/basin/watershed/geology/historic.html

Geology of the Boulder Area
Excerpted from "Boulder, A Sight to Behold: Guidebook" (1976) by Donald D. Runnells, modified by Sheila Murphy. Graphics adapted from Runnells by Erica J. Keefe.

WELCOME
TO THE ACTIVITY SECTION!

The watershed resource guide is divided into three sections.

LEVEL 1 ACTIVITIES

These activities provide ideas for presenting basic water and watershed information to students. The activities in this section include:

- **1.1** Water, Colorado's Precious Resource
- **1.2** The Water Cycle
- **1.3** The Boulder Water Story
- **1.4** Water Law and Supply
- **1.5** Water Conservation
- **1.6** Water Bingo—An Assessment

LEVEL 2 ACTIVITIES

These activities provide instruction on how to adopt a waterway and the types of actions your class can take. The activities in this section include:

- **2.1** StreamTeams—An Introduction
- **2.2** Mapping Your Watershed
- **2.3** Adopt-A-Waterway
- **2.4** Environmental Networks on the web
- **2.5** Watershed Walk
- **2.6** Waterway Clean-up: A Treasure Hunt
- **2.7** Storm Drain Marking

LEVEL 3 ACTIVITIES

These activities provide more in-depth monitoring of an adopted water way. The activities in this section include:

- **3.1** Assessing Your Waterway: Water Quality, a Snapshot in Time
- **3.2** Nutrients: Building Ecosystems in a Bottle
- **3.3** Assessing Your Waterway: Macroinvertebrates – Long-Term Ecosystem Health
- **3.4** Stream Gauging: A Study of Flow

WatershED

Boulder Creek/
St. Vrain
Watershed
Education

LEVEL ONE ACTIVITIES

Activity Level 1

ACTIVITY 1.1

WATER: COLORADO'S PRECIOUS RESOURCE

GRADES **4-12**
TIME **30-50** minutes

SCIENCE STANDARDS

#4.3 Students know and understand major sources of water, its uses and importance, and its cyclic patterns of movement through the environment.

OBJECTIVE

Students will…..
- be introduced to watershed concepts.
- discover how much water is on the planet and how much of it we can actually use.

BACKGROUND

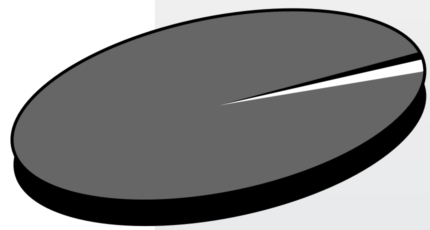
Water is the world's most precious resource. Besides being essential for life, it stabilizes our climate, irrigates our crops, and lights our cities. Although 80% of the Earth's surface is covered by water, only 0.5% is usable fresh water. Humans are just one aspect of the larger ecosystem that is Planet Earth, and we share this resource with plant and animal species who also need water to survive. Of the available fresh water worldwide, 5% is used by households; 75% by agriculture; and 20% by industry. In Colorado, 10% of fresh water is used in the cities, while 90% is used by the agricultural community.

Clean water is becoming harder and harder to find, thus we must take steps to protect and improve this resource. The impacts of population and pollution on water is the responsibility of us all. This unit on water strives to increase knowledge and understanding of water, watersheds, and environmental science, as well as providing students with tangible opportunities to become stewards of their local waterways.

MATERIALS

- Blowup Earth Ball
- Measuring tools (1000 ml beaker and smaller containers)
- Video "The Power of Water"
- Copy of student worksheet "All the Water in the World"

ALL THE WATER IN THE WORLD



Why is clean water getting harder to find?

(Population growth, migration to arid areas, pollution)

The earth is often referred to as the water planet. Why is that?

(80% of the earth is covered by water)

Activity Level

ACTIVITY #1

Demonstration with blow-up earth ball

Have students stand in a circle. Tell them to toss the globe back and forth to each other—spinning it when they throw it. Each time they catch it, have them tell where their right index finger lands. The teacher, or a student, should record where each student's finger falls when they catch the earth ball—ocean, land, lake. When everyone has caught the ball once, figure out the percentage of time people's fingers landed on water vs. land. Is it close to 80%?

Demonstration with milliliter beakers

The earth is 80% water, but not all of that water is fresh or accessible. This demonstration will help students visually understand what percentage of water is in the oceans, icecaps and glaciers, groundwater, fresh water lakes, inland seas and salt lakes, the atmosphere, and all rivers. After this activity they will understand that the amount of fresh water available for use is only a fraction of the water on the planet. See accompanying student worksheet.

ACTIVITY #2

Video

The National Geographic video "The Power of Water" is an excellent introduction to water issues, available from the WASH Education Outreach Coordinator. Length is 55 minutes. The video is divided into 5 sections: Columbia River (10 minutes), The Great Lakes (10 minutes), Everglades (10 minutes), Ogallala Aquifer (10 minutes) and the Colorado River and the Southwest (10 minutes). See accompanying video worksheet.

PEOPLE TO CONTACT

WASH Education Program 303-413-7365

REFERENCES

National Geographic Video "The Power of Water"

National Geographic Magazine
Nov 93 Water Issue
Mar 93 Ogallala Aquifer
Apr 94 Everglades
Feb 96 Stormwater Runoff

Project Wild Aquatic "How Wet is our Planet" pp. 8-10

STUDENTWORKSHEET1.1

"ALL THE WATER IN THE WORLD"

1. Start with 1 liter of water. One liter is 1,000 milliliters (ml). Imagine that this is all of the water on earth.

2. Measure the following amounts of water. Pour out the oceans water into a large container. Pour the other amounts into smaller containers and label them.

Oceans	972 ml
Icecaps and Glaciers	20 ml
Groundwater	6 ml
Freshwater Lakes	1 ml
Inland seas and salt lakes	1ml
Atmosphere	0.1 ml (1/10 ml)
All rivers	0.01 ml (1/100 ml)

3. How much water is fresh water?

4. Can people really use all of this fresh water? Why? Why not?

VIDEOWORKSHEET1.1

NATIONAL GEOGRAPHIC'S "THE POWER OF WATER"

List the many metaphors for water that are used in this video.

Columbia River

1. Why is the Columbia called a freeway for salmon?

2. Salmon were called "the canary in the coal mine." What does this term mean and why was it used in this instance?

The Great Lakes

3. How much of the world's fresh water is stored in the Great Lakes?

4. What are PCBs used for? What are other pollutants mentioned in the video? Why are they bad for humans and fish?

5. Why was the class stenciling "Dump No Waste: Drains to River" onto storm drains?

Everglades

6. Why does the narrator say "the Everglades are dying of thirst?"

7. How are people in South Florida trying to reverse the decline of the Everglades?

1 Activity Level

Ogallala Aquifer

8. Where does water come from in an aquifer? How far does the farmer say groundwater levels have dropped in his area?

9. What is dryland framing? How much more land is needed for dryland farming as opposed to irrigation farming?

10. How might new technology help the farmers? Would your suggestions benefit them in the short-run or the long-run?

Colorado River and the Southwest

11. The narrator states that moving water from one place to another is a "western obsession." Why is this the case and how does it relate the Boulder Water supply and other cities in the Front Range?

12. What 7 states use water from the Colorado River? What about Mexico?

13. What are some solutions to Las Vegas water shortages? Who would benefit and who would be adversely impacted?

ACTIVITY 1.2

THE WATER CYCLE: A DEMONSTRATION

GRADES **4-8**
TIME **30** minutes

This activity is adapted from the USGS site: http://www.ga.usgs.gov/edu/watercycle-graphic.html

SCIENCE STANDARDS

#4.3 Students know and understand major sources of water, its uses and importance, and its cyclic patterns of movement through the environment.

OBJECTIVE

Students will….
- become familiar with the complex water cycle system.
- label the major parts of the water cycle on a diagram.

BACKGROUND

The Earth is a closed ecosystem. All the water we have is on the planet; as it goes through the water cycle, it is changed from one form to another. The three states of water are solid, liquid and vapor. Most of the precipitation that we get in Colorado falls in the form of snow in the mountains. Coloradans rely heavily on the snowfall not only for recreation but also for water supply. We get 80% of our drinking water from snowpack.

The water cycle or hydrologic cycle is a complex system. The hydrologic cycle and its major parts are defined below:

Hydrologic Cycle (Water Cycle): water in its various manifestations as vapor evaporated from oceans, lakes, streams, and plants; rain and snow; snowpack or glacier; groundwater or surface runoff; and finally as streams and rivers returning to the sea.

Surface water: water that is on the Earth's surface, such as in a creek, stream, river, lake, ocean, or reservoir.

Evaporation: the sun evaporates water from ponds, lakes and the ocean and converts it to vapor or gas, which eventually cools and turns into clouds.

Precipitation: water that falls in the form of rain or snow from saturated clouds.

Infiltration: water that reaches the earth, either runs off the surface, falls into a surface waterbody, or infiltrates into the soil to collect underground.

Transpiration: underground water may be soaked up by plant roots and carried into their leaves. Water vapor is a by-product of plant transpiration, which uses solar energy, water and nutrients to create nutrients.

Respiration: when we breathe, small amounts of water vapor are released from our lungs.

1 Activity Level

Runoff: precipitation that flows overland to surface creeks, streams, rivers, and lakes.

Groundwater: water that sinks into the ground and collects over impermeable rock. It then flows laterally toward a stream, lake, or ocean. Wells tap it for our use. Its surface is called the "water table."

Water Table: The upper surface of the groundwater; the level below which the soil is saturated with water. Its depth is influenced by rainfall and by human development (wells, drainage ditches, loss of wetlands, etc.).

Does the rain appeared colored?

(Rain generally has less dissolved materials unless materials from volcanoes, dust, or pollution are in the air)

MATERIALS NEEDED

The Hydrologic Cycle diagram that illustrates the major parts of the water cycle.

ACTIVITY

Provide a blank hydrologic cycle diagram and have students label the major parts of the water cycle or make a water mobile. Once finished, have the students make a list of all the places that water goes once it reaches the ground and describe each location. Then, have students choose two of the following locations and describe what happens to a drop of water (precipitation) after it lands on the chosen location. Have the students include a sketch or drawing with their description.

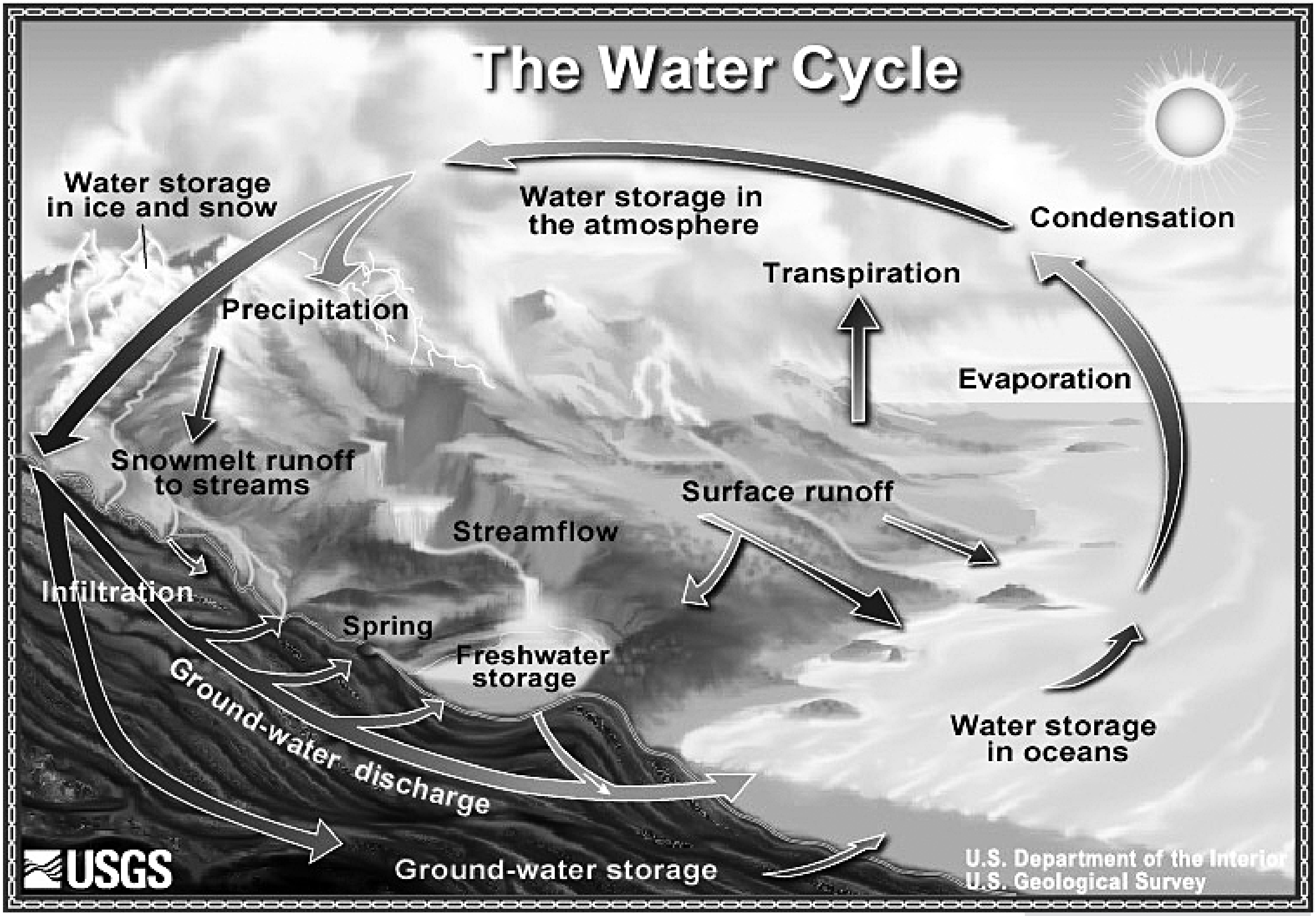
- School Parking Lot
- Storm Drain
- Mountain
- Boulder Creek
- Barker Reservoir
- Office Building Roof
- House
- Grassy Field
- Street
- Slide in a Park
- Glacier
- Forest

DISCUSSION QUESTIONS:

1. What are the three states of water?
2. List at least three kinds of precipitation.
3. Where does most of the precipitation fall in Colorado? What form is it in?
4. What happens to precipitation once it reaches the ground?
5. List two ways that water is naturally stored (not by people).
6. Are you drinking the same water as the dinosaurs?
7. If water enters a storm drain, where does it go?

EXTENSIONS:

Project WET activities: Imagine! (157-160) and The Incredible Journey (161-165) are good enhancements to the above water cycle discussions and activities.



Activity Level 1

WatershED Activity 1.1

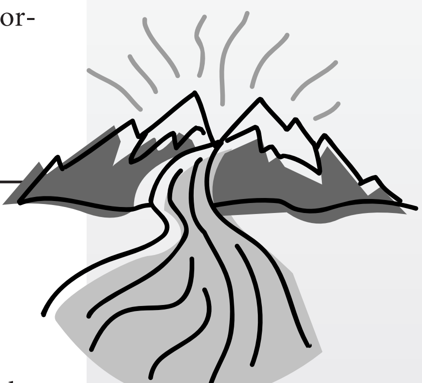
ACTIVITY 1.3

BOULDER WATER SUPPLY STORY:
SNOW CAPS TO WATER TAPS AND BEYOND

GRADES **4-12**
TIME **45-60** minutes

SCIENCE STANDARDS

#4.3 Students know and understand major sources of water, its uses and importance, and its cyclic patterns of movement through the environment.



OBJECTIVE

Students will…
- learn about the three water systems (drinking, wastewater, and stormwater),
- gain a historical perspective of water uses, and
- discuss challenges and choices facing us today.

NOTE: This activity focuses on the treatment plants for Boulder; if you live outside the city, you can find out where your drinking water and wastewater are treated.

"…Boulder's water supply system used to consist of a glacier and sun. The sun melted the glacier into water and the water ran down the creek into the city. Citizens put in a few pipes and pumps to bring the water to them. That was all."

Andy Briscoe,
City of Boulder

BACKGROUND

It is important for people to understand where their water comes from, the process it undergoes before it arrives at the tap, and where it goes once we've used it.

Like most Colorado communities, Boulder depends on stored water most of the year. High streamflows from melting snowpack occur for only a few spring and summer months. This water is captured in reservoirs. Natural stream flows in late summer and winter are not sufficient to meet consumer demands and must be supplemented with releases from reservoirs. The amount of water that is available for use varies from year to year and depends on snowpack in the mountains.

On average from year to year, about 40 percent of the city's water supply comes from the Silver Lake/Lakewood Watershed on North Boulder Creek, 40 percent from Barker Reservoir on Middle Boulder Creek, and 20 percent from Boulder Reservoir sources. The Silver Lake/Lakewood Watershed and Barker sources are used as much as possible every year without reducing drought reserve supplies. As Boulder grows, the percentage of water delivered directly through the Boulder Reservoir Water Treatment Plant will increase to about one-third of the total supply on average. The city owns enough additional water at Boulder Reservoir to meet all of Boulder's future needs.

Water from Barker Reservoir is treated, along with the Silver Lake/Lakewood Watershed supply, at the Betasso Water Treatment Plant. Most of the water treated at the Boulder Reservoir Water Treatment Plant comes from the Colorado Big Thompson (CBT) and Windy Gap Projects. These projects divert water from the upper Colorado River on the western slope and bring it to northeastern Colorado through a series of tunnels, canals and reservoirs.

Boulder’s wastewater is collected in sanitary sewer pipes and delivered to the 75th Street Wastewater Treatment Plant. Here the used water undergoes extensive treatment including: settling, filtering, solids contact, and chlorination/dechlorination before it is discharged into Boulder Creek for users downstream.

The third set of water pipes are those that collect stormwater runoff from streets, parking lots, roofs and other surfaces via storm drains and carry it to the nearest creek. These storm drains are connected directly to creeks and ditches in Boulder. What this means is that anything that gets picked up by stormwater such as litter, fertilizer, oil, leaves, pet waste and more is discharged directly to a creek. It is important that we work to keep our streets, yards and parking lot clean in order to keep our creeks clean.

See accompanying student worksheet.

Drinking Water source information for surrounding communities:
Louisville: South Boulder Creek and water from the Northern Colorado Water Conservancy District
Lafayette: South Boulder Creek
Longmont: North and South St Vrain Creeks, St. Vrain Creek; the Colorado and Fraser Rivers in Grand County via the Colorado-Big Thompson (C-BT) and Windy Gap Projects; and from the Ralph Price Reservior (Button Rock Preserve).

Lyons: North and South St Vrain Creeks, St. Vrain Creek
Nederland: Middle Boulder Creek
Broomfield: Carter Lake
Superior: Lake Granby, Carter Lake and Terminal Reservoirs
Gold Hill: Individual Private Wells
Jamestown: James Creek
Erie: Carter Lake and Eire, Prince and Thomas Reserviors
Frederick: Carter Lake
Mead: Little Thompson and the Northern Colorado Water Conservancy District
Niwot: Lefthand Creek Basin and the Northern Colorado Water Conservancy District

Q:

Review watershed map:

Can you find the drinking water sources?

Wastewater from these communities is returned to the following water sources:
Louisville: Coal Creek
Lafayette: Coal Creek
Longmont: St. Vrain Creek
Lyons: St. Vrain Creek
Nederland: Barker Reservoir
Broomfield: Big Dry Creek
Superior: Lake Granby, Carter Lake and Terminal Reservoirs
Gold Hill: Individual Sewage Disposal Systems (ISDS)
Jamestown: Individual Sewage Disposal Systems (ISDS)
Erie: Coal Creek
Niwot: Dry Creek which continues to the St. Vrain

MATERIALS

Map of Boulder Creek/St. Vrain Watershed
Check out Boulder Water Story — video
Copies of “The Boulder Water Story” Student Video Worksheet
Check out Water History Trunk

Activity Level 1

ACTIVITY

Boulder's Water Story — 13 minute video

Water History Trunk

1. Start this session by watching Boulder's Water Story. This video lays out the Boulder water supply system. It discusses the three major sources of drinking water supply and reviews drinking water and wastewater treatment. It provides a good overview of the water supply system — which will lend itself to further discussions including: water quality, urban development, water pollution, interconnection of humans and environment, and more.
2. After viewing the video, you can transition into a discussion about the history of Boulder's water supply. Contact your local water department for additional information.
3. The Water History Trunk (a collection of antique water artifacts) is available for check out from the WASH Education Program. For this activity, arrange artifacts on a table for the students to browse through. After all students have had the opportunity to review the items, pick one out and have a volunteer from the class explain what it is and how/why it was used. Do this with each of the items as time permits.

HISTORICAL SKETCH

Settlers arrived in the Boulder area in 1858. They were lured westward by the tales of gold discoveries in the Rocky Mountains. The first groups of settlers, lead by Capt. Thomas Aikins, arrived at the mouth of Boulder Canyon below Red Rocks at "Settlers' Park."

Small gold veins were found in several places throughout the foothills, with the most notable discovery in Gold Hill. However, the abundance of gold was not what they had expected. During the spring of 1859, some of the discouraged gold seekers moved east to the Boulder area. The town of Boulder would grow quickly; in fact, the town prospered with new businesses, banks and educational institutions.

The town of Boulder realized in the 1870's that in order to have dependable water supplies throughout the year, they would have to build a reservoir. The first reservoir, complete with a sand filter, was built in 1875. Water flowed down to Pearl Street through an 8-inch cast iron pipe to the public square (site of the Boulder County Courthouse) which lay 160 feet below the elevation of the reservoir. Many Boulder residents got their water at the public square. The trip to town for water became a social event; citizens took time to visit, perhaps watch a baseball game between Boulder City and Sunshine, and then trudge home with full pails.

In the early 1900's the city realized that it would need to secure more drinking water sources if the area was to support a thriving town. One of the head figures in developing the city's drinking water plan was Eben G. Fine, whom we have named a city park after.

What follows is an account by Eben G. Fine of the Boulder water supply plan:

In 1900, I discovered Arapahoe Glacier. Six years after this discovery, the city of Boulder purchased Silver Lake from James P. Marshall. Later, other lakes in the

FACT:

In Colorado, roughly 80% of our water supply comes from snow.

Boulder Creek Watershed, together with twenty three hundred acres of land on either side of the stream flowing from Silver Lake, forming North Boulder Creek were purchased. The purpose of this purchase was to being safeguarding the purity of the water by closing off the area and patrolling the stream from the lake to the city's storage reservoir a few miles below.

In 1919, a bill was introduced in the Congress and passed, enabling the city of Boulder to purchase out of the Roosevelt National Forest, three thousand six hundred ninety five acres of land, including Arapahoe Glacier and the entire Silver Lake/Lakewood/Arapahoe Watershed, as the source of the city's water supply. The purchase was completed and the money paid over to the Government in 1925.

ANSWERS TO VIDEO REVIEW

1. **What are the three sources of Boulder's drinking water?**
   Silver Lake/Lakewood Watershed (40%), Barker Reservoir (40%) and Boulder Reservoir sources (20%).
2. **What are the advantages/disadvantages to piping our water from Silver Lake and Barker to the Betasso Drinking Water Plant?**
   Advantages: Water does not evaporate out of the pipes, and it cannot be contaminated.
   Disadvantages: It is expensive to build and maintain pipelines; pipelines are not beautiful like a flowing stream.
3. **What are the advantages/disadvantages to using reservoirs as a drinking water source and a place for recreation?**
   Advantages: it provides two things — water and fun — from the same body of water.
   Disadvantages: recreation can add pollutants to the water that make it more difficult to treat.
4. **What is the average rainfall for the Boulder County region?** (18 inches/yr)
5. **List several ways that you conserve water.**
6. **We cannot make more water for our use; all the water that is available to use is right here on Earth. Knowing this, what types of actions should we take with regards to water pollution, water quality, and conservation?**

EXTENSION

1. Have students do research on the history of water in their commuity. Examples include:
- Historic water uses in Boulder County (mining, farming, etc).
- Ditches: Who owns them? Who uses them? What are they for?
- Hydropower

2. Call your local water provider for a tour of a water treatment plant.

KEY WORDS

Coagulation
Filtration
Sedimentation
Chlorination
Storm drains

PEOPLE TO CONTACT

WASH Education Program 303-413-7365
Wastewater Treatment Plant 303-413-7340
WWW sites: www.basin.org

REFERENCE

Phyllis Smith. *A History of the Waterworks of Boulder*, CO. April 1986.

VIDEOWORKSHEET 1.3
BOULDER WATER STORY

1. What are the three sources of Boulder's drinking water?

2. What are the advantages/disadvantages to piping our water from a reservoir to a treatment plant?

3. What are the advantages/disadvantages to using reservoirs as a drinking water source and a place for recreation?

4. What is the average rainfall for Boulder County?

5. List several ways that you conserve water.

6. We cannot make more water for our use; all the water that is available to use is right here on Earth. Knowing this, what types of actions should we take with regards to water pollution, water quality, and conservation?

Activity Level 1

ACTIVITY 1.4

WATER LAW AND SUPPLY

GRADES
4-12
TIME
30-50
minutes

SCIENCE STANDARDS

#5 Students know and evaluate interrelationships among science, technology, and human activity and how they can affect the world.

OBJECTIVE

Students will…

- enact the challenges of water resource management and
- simulate the Prior Appropriation law that governs water supply in Colorado. This activity will show how science operates within the social constructs of the law.

BACKGROUND

Water is essential to life. It is used to generate power, irrigate crops, for drinking water, and to support various ecosystems. Colorado has an arid climate, with most precipitation falling as snow during the winter far away from the population centers in the Front Range. Boulder receives approximately 18 inches of precipitation a year. Snowmelt during the spring creates a surge of water that flows down through the rivers and creeks. Often during the remainder of the year the majority of the rivers and streams are too low to provide for the multiple users. To overcome this seasonal scenario, water is dammed and stored. Water is our most managed resource.

As a result of the scarcity of water in the West, complex water distribution systems, water laws, and water agencies have been developed to manage this precious resource.

Q:

What role has science played in water management?

1. **Engineers and dams**
2. **Wildlife management**
3. **Drinking water**
4. **Climatologists**

COLORADO WATER LAW

Settlers migrating west quickly realized that western land and water resources were much different than those in the humid eastern region they had come from. Due to the aridity of the West, miners had to develop a new system for water allocation and use. The water allocation system used in the East, the Riparian Rights or Common-Law Doctrine, is tied water to adjoining lands, and therefore, would not work in a region where much of the usable land was not adjacent to the rivers and streams. The solution to Western water allocation was found in the Prior Appropriation Doctrine, "first in time, first in right", which was born in the hills of California where miners battled it out for unlimited use of water for their mining operations. The Prior Appropriation Doctrine was later adopted by farmers who started diverting rivers for irrigated farming.

The Prior Appropriation Doctrine also controls the distribution of water in Colorado. Those water users that were here first have "senior" rights and get first call on water. However, they can only use as much as they have used in the past. Use is defined as

1 Activity Level

"beneficial use," which can be very loosely interpreted. "Beneficial use" in the Colorado Constitution gave top priority to domestic use, second priority to agricultural use, and third to manufacturing use.

The first time local water rights were adjudicated, or recognized by the Boulder County District Court was in 1882. Ninety-eight ditch companies were accorded a priority right and irrigation ditches were constructed to bring water from South Boulder Creek, the St. Vrain River, Boulder Creek, and the Big Thompson River to irrigate the area's first crops of wheat and turnips.

Today, many streams are over allocated, that is that every drop of water is spoken for by a user. Sometimes there is not enough water left for the fish and other organisms that use the stream.

Because water has many users it is important to understand that managing water involves tradeoffs. Extensive negotiation along legal, scientific, and social lines occurs when determining how to distribute water. Clean drinking water might have to be balanced against leaving sufficient water in the stream for aquatic life, agriculture might have to be balanced against hydroelectric generation.

This activity will examine how the water appropriation system operates.

MATERIALS

1-2 Jugs Lemonade
Index Cards (or similar)
Paper Cups

ACTIVITY

Prepare index card with the following information:

Water User Type
Year Established
# of Acre Feet (one acre foot = one cup)

For example:

Water User Type	Agriculture
Year Established	1895
# of Acre Feet	2

Water User Type	Hydroelectric
Year Established	1967
# of Acre Feet	18 (but returns 16 back to the Jug)

Water User Type	In-Stream Flow (Trout Unlimited)
Year Established	1987
# of Acre Feet	1.5

Q:

Why did settlers first come to Boulder?

Why are they still coming? And how does this effect water supply for the region?

Who defines benefi-cial use?

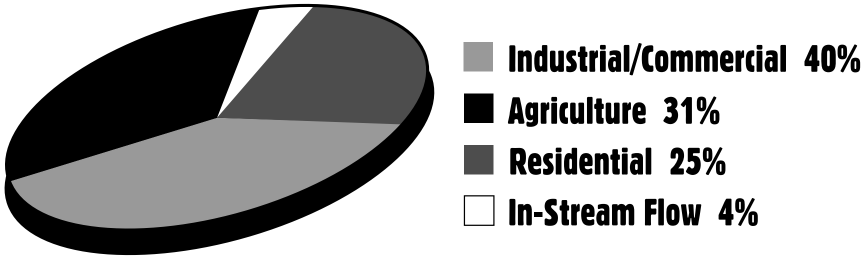
FACT:

The Gunnison River is one of the only under allocated streams in Colorado.

Activity Level 1

WatershED
Activity 1.4

Develop a framework that matches the water use of historical development in Boulder County.



Water Use in Boulder County (1995)

Historical Rank (will vary)

1. Agriculture
2. Mining
3. Municipal
4. Industrial
5. Hydroelectric
6. Recreation
7. In-Stream Flow
8. More Municipal
9. More Industrial

As the class files into the room hand them slips of paper that indicate the type of user they are, and their seniority. First in Time, First in Right.

Those students first to class have the most senior water rights.
Have each student sit in order of their "seniority", and give them a cup. After the entire class has entered the room and had a seat introduce the subject, the law or prior appropriation.

Begin allocating water rights.
The teacher acts as the district water manager. Each student may claim as much acre-feet (cups) as they have been allocated. For example, the most senior user has one cup and you are half way through the class. That senior user can call for one more cup at any time and the teacher must provide that "water" to the more "senior" water user before distributing water to those holding "junior" rights. Eventually, all the water is used up before the rest of the class gets to exercise their water right. It is useful to have an extra jug of lemonade available for all students to enjoy after the activity.

QUESTIONS?

1. Is this system fair?
2. Is this system scientific?
3. How is science used to reinforce/alter the system (groundwater is often tied to surface water, and hydrologists debate the connection)?

Q:

How has the history of the region been influenced by water distribution?

Why is this the order of seniority?

What other factors influence seniority?

In your own words, describe what "First in Time, First in Right" means.

1 Activity Level

KEY WORDS

Acre-foot: the amount of water that would cover one acre at a depth of one foot (325,900 gallons). It is enough water to meet the inside, lawn watering, and industrial needs of 4-5 urban people for one year.

Prior Appropriation Doctrine: "first in time, first in right."

Water rights: legally established right to appropriate water from a given location.

In-stream flow: water rights that are used to insure enough water remains in the stream to support aquatic life.

REFERENCES

Smith, Phyllis. A History of the Waterworks of Boulder, Colorado. April 1986.

Reisner, Mark. Cadillac Desert. 1987.

Q:

Many people are concerned that senior water users (agriculture) are selling their rights for development. What are some of the choices we have to face with development and loss of agricultural lands?

Where does the majority of Boulder's water come from?

80% from the upper reaches, 20% from the Colorado River, see Activity 1.1

ACTIVITY 1.5
WATER CONSERVATION

GRADES **4-12**
TIME **see** below

SCIENCE STANDARDS

#5 Students know and evaluate interrelationships among science, technology, and human activity and how they can affect the world.

#6 Students understand that science involves a particular way of knowing and understanding common connections among different scientific disciplines.

OBJECTIVE

Students and their parents will…
- become aware of the many different ways they use water, and
- introduce them to simple conservation steps they can take.

BACKGROUND

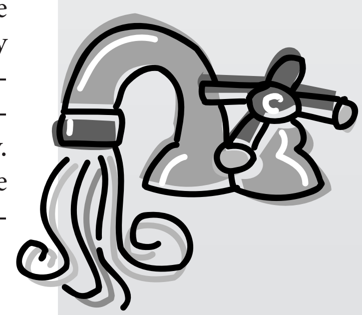
The Boulder County region receives an average of 18 inches of rain a year which is not enough precipitation to depend on for all of our water needs. We rely heavily on the snow that falls in the mountains. In Colorado, roughly 80% of our water supply comes from snow. Because snow melts quickly in the spring, we have developed extensive reservoir systems throughout the mountains and plains to store water for year-round use. The average Boulder County resident uses about 80 gallons of water a day. This amount fluctuates throughout the year. The highest demand for water falls in the summer months—June, July, August. The most water we use indoors is in the bathroom. The highest water use outdoors is for landscape irrigation.

Because water is a precious resource in Colorado, we must find ways to conserve it. There are many things we can do indoors to reduce the amount of water we use including putting in low-flow showers and toilets; turning off the water when we brush or shave; taking shorter showers; and many others. Much of the water we use is for outdoor watering. One way to reduce our watering is to plant a xeriscape landscape that incorporates native, drought resistant plants, trees and grass species.

In Boulder, our houses and apartment buildings have water meters that measure household water use. The city of Boulder's Public Utility Department takes monthly readings from our water meters to prepare household water bills and to calculate a community's water use.

Time required

Two15 minute class periods for discussion (before and after survey), and one week to complete home water use survey



Activity Level 1

MATERIALS

Copies of “Personal Water Use” and “Water Conservation Chart” Student Worksheets
2 or 3 gallon jugs

See accompanying student worksheet.

ACTIVITY #1

1. Discuss daily water uses with students. Talk about how much water it take for different activities (e.g., flushing the toilet used between 1-5 gallons of water/flush).
2. Pass out copies of the Personal Water Use worksheet and explain to the students that for the next week they are to keep track of their water use.
3. At the end of the week, have students figure out their average daily water use in gallons/day. How can students reduce their average gallons/day? Have students make a conservation pledge listing ways that they can reduce the amount of water they use.

ACTIVITY #2

This activity will help students appreciate how often they use water daily.

1. Tell students that for one week the only water the class can use is what is kept in the gallon jugs in the classroom. They have to use it for their drinking water, to wash their hands, for water classroom plants, etc.
2. Designate a spot in the school to be the “well” where students will go to “draw” water when the gallon jugs go dry. The well should be located somewhere far from the classroom, such as a faucet in the basement or across the school.
3. Discussion Questions: Do students use less water when they know they have a limited supply? Is it a pain to have to fill it up at the “well” each time they run out of water? What things would they do differently if they had to draw water from a well instead of just turning on the tap in the kitchen?

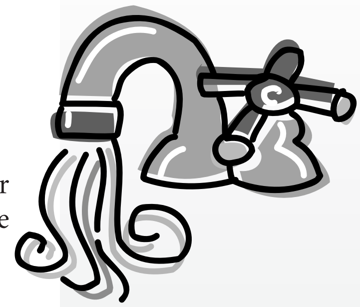
EXTENSION

Students may try this activity at home for a day or a week with their family and write a page about their family’s reactions.

PEOPLE TO CONTACT

Water Education Program 303-413-7365

STUDENTWORKSHEET1.5
PERSONAL WATER USE



Student Name____

For each water use, write the estimated number of gallons used. Keep track of your water use for each day, for a week. At the end of the week you will be asked to figure out your average daily use.

WATER USES	Monday	Tuesday	Wednesday	Thursday	Friday
shower/bath					
flushing toilet					
brushing teeth					
drinking water					
washing hands					
washing clothes					
washing dishes					
dishwasher					
outdoor watering					
Daily Total:					

Average water amounts for each use:

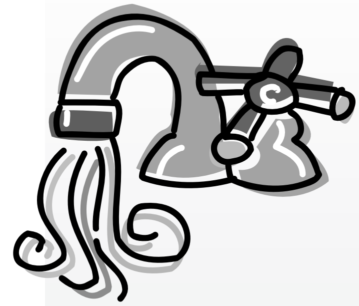
shower/bath ~ 2.5-10 gallons/minute
washing dishes ~ 30 gallons (water running)
flushing toilet ~1-5 gallons/flush
brushing teeth ~ 1-5 gallons (water running)
drinking water ~ 1/8 gallon/cup of water
washing hands ~ 1-5 gallons/minute
dishwasher ~ 20 gallons (÷ number in household)
washing clothes ~ 50 gallons/load (÷ number in household)
outdoor watering about 8 gallons/minute (÷ number in household)

To find daily average water use: Add Daily Totals ÷ 5 = average gallons/day

_____________ ÷ 5 = _____________ average gallons/day

STUDENTWORKSHEET1.5

WATER CONSERVATION CHART



Student Name____

Water Use	Water Amounts (No Conservation)	Conservation Methods	Water Amounts (With Conservation)
shower/bath	~5 gallons/minute or 25 gallons for 5 minutes	Install low flow shower head. Wet & soap, rinse off.	~5-10 gallons for quick shower
flushing toilet	~5 gallons/flush	use tank displacement. Flush less frequently.	~2-3 gallons/flush
brushing teeth	~2 gallons (water running)	use glass to wet brush and rinse	1 pint
washing hands	~2 gallons (water running)	wet hands, turn off water, lather, rinse	1 quart
washing clothes	~40 gallons/load (top water level)	use minimum water level	25 gallons
washing dishes	~30 gallons (water running)	wash, rinse in tub	5 gallons
dishwasher	~20 gallons/load (full cycle)	use short cycle	7 gallons
outdoor watering	~8 gallons/minute	water less	

Monthly Water Use Average Before Conservation Methods ____________

Monthly Water Use Average After Conservation Methods____________

Total Water Conservation____________

Activity Level 1

GRADES **4-12** (depending on terms used)
TIME **30-50** minutes

ACTIVITY 1.6

ASSESSMENT AND REVIEW: WATER BINGO

SCIENCE STANDARDS

#4.3 Students know major sources of water, its uses, importance, and cyclic patterns of movement throughout the environment.

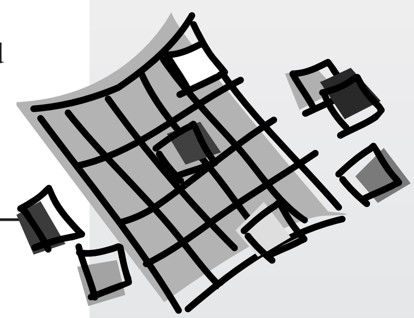
#5 Students know and understand ways science, technology, and human activity can affect the work and its resources.

#6 Students understand that science involves a particular way of knowing and understanding common connections among different scientific disciplines.

OBJECTIVE

The students will…

- play a game of bingo to review the terms covered in the section 1 activities, and
- jot down unfamiliar terms to further study for quiz.



RULES

1. No partners, each student should do his/her own bingo sheet.
2. Anyone shouting out answers is disqualified from that round.
3. Once bingo is called and the student's card checks out to be correct, everyone removes their markers and starts with a clean sheet.
4. Winners get a prize (Fish bumper stickers, etc.)

MATERIALS

Bingo sheets
Colored paper markers
Prizes

ACTIVITY

1. Give each student a bingo sheet and a handful of colored paper makers.
2. Write twenty-four of the terms (listed later in this lesson) on the board or overhead.
3. There are enough to do two different rounds of terms (24 per bingo sheet).
4. Have the students write the 24 terms anywhere they would like on their bingo sheet, leave the middle clear as a free space. Once the class is ready, begin reading the definitions and explanations of terms. Give students time to think. The students then place a paper marker on the term they believe the teacher has just described or defined.
5 The teacher must remember to mark the terms read, so as not to repeat terms in the same game, and also in order to check to see if the student calling bingo is actually correct.

Activity Level 1

6. When a student yells bingo, go to his or her desk and check to see if the terms are correctly marked. If their is an error on the student's part, have him/her remove that marker and continue the game.

7. When a game is won, the winner gets to pick one prize. Have students clear their cards, and begin again.

8. Once students have exhausted one set of terms, put the next set on the board or overhead, and repeat the game.

Students have spent time performing activities #1.1-1.5 (or similar) and thus should be able to define all of the terms provided.

WATER BINGO QUESTIONS AND ANSWERS

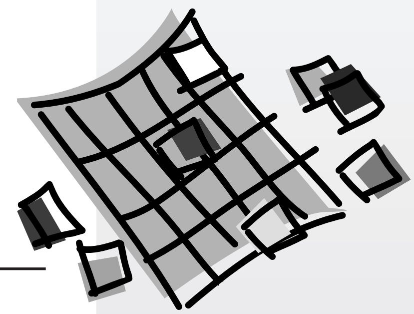
GENERAL

In what wilderness area does Boulder Creek have its headwaters?
Indian Peaks Wilderness Area

In what wilderness area does St. Vrain Creek have its headwaters?
Indian Peaks Wilderness Area

What is it called when water is diverted from one river basin into another?
transbasin diversion

When water is left in a river for aquatic life this is called?
minimum streamflows



GEOGRAPHY/SCIENCE

Most of Colorado's precipitation falls in which portion of the state?
mountains

Name the 3 physical forms of water.
liquid, solid and vapor

How much of the earth's surface is covered by water?
80%

How much of the water on earth is usable fresh water?
0.5%

What is an acre-foot, and how many gallons are there in an acre-foot of water?
1 acre, 1 foot deep; 325,900 gallons

An acre-foot of water is enough to meet the inside-home, lawn watering and industrial needs of how many urban people for one year?
4-5

What is the significance of the Continental Divide to water supplies?
this is where water flows east to the Atlantic or west to the Pacific

What major river in Colorado does Boulder Creek eventually feed into?
South Platte (Boulder Creek > Saint Vrain > South Platte > Missouri River > Mississippi > Gulf of Mexico)

What major river in Colorado does St. Vrain Creek eventually feed into?
South Platte (Saint Vrain > South Platte > Missouri River > Mississippi > Gulf of Mexico)

What major river in Colorado does Coal Creek eventually feed into?
South Platte (Coal Creek > Boulder Creek > Saint Vrain > South Platte > Missouri River > Mississippi > Gulf of Mexico)

What is a watershed?
the area drained by a river or stream and its tributaries

WATER CYCLE

What is the name of the water cycle process by which water changes from a liquid to a vapor?
evaporation

What part of the water cycle occurs when no water can infiltrate through parking lots and streets?
runoff

How does water enter our local creeks from paved roads and parking lots?
through storm drains

What is the name of the portion of the water cycle where water vapor is transmitted through the pores of leaves into the atmosphere?
transpiration

What is the name for the portion of the water cycle where solid or liquid water falls to the earth's surface?
precipitation

What is the process called when water changes from a vapor to a liquid or solid state, such as within a cloud?
condensation

What is the energy source that drives the water cycle?
the sun

WATER SUPPLY

What percent of Colorado's water supply comes from snowpack?
80%

What is Boulder County's region's average annual precipitation?
18 inches/year

What is Boulder County's region's potential loss to evaporation?
55 inches/year

Name the three sources of drinking water for Boulder.
Silver Lake/Lakewood Watershed, Barker Reservoir, Boulder Reservoir sources

Name the sources for the city of Longmont's drinking water.
St. Vrain Creek watershed, the Colorado and Fraser Rivers in Grand County, and the Ralph Price Reservoir (Button Rock Preserve) and Burch Lake which are used to store water before it is treated.

Name the sources for the city of Louisville's drinking water?
South Boulder Creek and supplemented as well from the Northern Colorado Water Conservancy District via Carter Lake.

Name the sources for the town of Superior's drinking water?
Lake Granby, Carter Lake and Terminal Reservoirs

Name the sources for the town of Erie's drinking water?
Carter Lake and Erie, Prince and Thomas Reservoirs

Where does water in the Colorado-Big Thompson system come from?
headwaters of the Colorado River in Rocky Mountain National Park

This reservoir stores the Colorado-Big Thompson water near the City of Boulder?
Boulder Reservoir

Colorado-Big Thompson water enters Boulder Reservoir through?
the Boulder feeder canal

WATER RIGHTS/ADMINISTRATION

Name the system of water allocation in Colorado, and explain how it works.
Prior Appropriation Doctrine, "first in time, first in right"

What agency is responsible for administering water rights in Colorado?
State Engineers Office

How are disagreements over water rights handled?
in water court

The system of water law used in Colorado is sometimes referred to as the "Colorado Doctrine." What is the technical name?
Prior Appropriation Doctrine

WATER CONSERVATION

Where is most of the treated water used in western cities?
in the landscape

What is xeriscape?
water conserving landscape

What are three ways to use less water for bathing or showering?
install a low-flow shower head, take a shorter shower, fill the bathtub only half full

When is the highest demand for water in the Boulder County region?
in the summer months of June, July and August

WATER USE

In Colorado, what percentage of water use is by cities and what percentage by agriculture?
10% city, 90% agricultural

Name two instream uses of water.
habitat protection, recreation

How much water does the average person in Boulder County use in a day?
80 gallons

How is water used worldwide?
5% for human use/consumption, 75% for agriculture, 20% for industry

What room of a house typically has the highest water use?
bathroom

How much water is used in a single toilet flush?
1-5 gallons

How much water is does it take to produce on hamburger? (Take into consideration all the uses of water, such as irrigating the grain to feed the steer.)
600 gallons

Name six categories of water use.
agricultural irrigation, landscape irrigation, drinking, wildlife habitat, cleaning, cooking, cooling, industrial/commercial, transportation, recreation, transporting wastes, heating, fighting fires, power production

WATER TREATMENT

Where does the water from lakes and rivers go to be cleaned so that it is safe to drink?
water treatment plant

At the water treatment plant, water is treated by which two processes?
physical and chemical

Why are water treatment plants located at a point higher than the city?
to take advantage of gravity and minimize the amount of pumping necessary to build up the water pressure

What chemical is added to our municipal water to kill disease germs?
chlorine

Why isn't it safe for hikers and backpackers to drink water directly from the streams in Colorado?
stream water may contain impurities such as dirt and disease germs that can make you sick

Name the two drinking water treatment plants in Boulder?
Betasso and Boulder Reservoir

Name the three drinking water treatment plants in Longmont?
The North, the South, and the Wage Gaddis Water Treatment Plants.

WASTEWATER TREATMENT

Where does all the water and wastes from sinks, bathtubs, and toilets go to be cleaned before the water is put back into the river?
to the sanitary sewer system and then the wastewater treatment plant

Does the water that enters the storm sewer system undergo wastewater treatment?
No, only the water that enters the sanitary sewer system undergoes wastewater treatment.

Why are wastewater treatment plants located at points lower than the city?
since sewage from the city's homes and businesses flows by gravity, and is not pumped, the wastewater treatment plants must be located at a lower point

After wastewater is treated where does it go?
back to creeks and rivers. In Boulder, it is returned to Boulder Creek. In Longmont it is returned to St. Vrain Creek.

STORMWATER

Name the two different types of sewer systems in the Boulder County region.
storm sewer and sanitary sewer

Where does runoff from rain and snow go?
the storm sewer system via storm drains and then into Boulder's creeks

Does runoff increase or decrease in urban areas?
increase

Why should motor oil, paints or other materials never be dumped in storm drains?
because storm drains connect to creeks; these materials may be harmful to fish and other wildlife

What are some of the "other materials" that might enter the storm drain system when it rains?
pet waste, fertilizers, pesticides, construction debris, mining wastes, car wash detergents, etc.

Why is groundwater recharge less in urban areas than in natural areas?
urban areas have more impervious surfaces (such as parking lots) that water can not seep through

WatershED

Boulder Creek/
St. Vrain
Watershed
Education

LEVEL TWO ACTIVITIES

Activity Level 2

ACTIVITY 2.1

STREAMTEAMS—AN INTRODUCTION

GRADES **4-12**
TIME **30** minutes

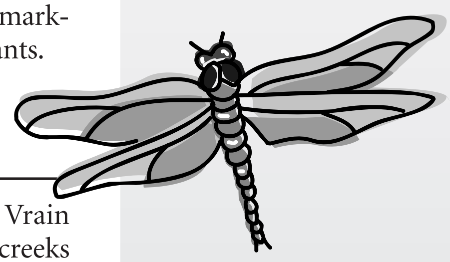
SCIENCE STANDARDS

#5 Students know and understand ways science, technology, and human activity can affect the work and its resources.

OBJECTIVE

By participating on a StreamTeam the Students will…

- discover the educational value of the natural environment by taking responsibility for a local water body, and
- implementing a variety of stewardship practices that may include: storm drain marking, monthly creek cleanups, planting native plants, and pulling non-native plants.



BACKGROUND

Boulder Creek is the primary creek in the Boulder Creek watershed. The St. Vrain Creek is the primary creek in the St. Vrain watershed. But these are not the only creeks in these watersheds. There are hundreds of tributaries (creeks that feed into Boulder and St. Vrain Creeks), ponds, lakes and wetlands to be explored and protected. Creeks are an important backbone to a healthy environment. Healthy creeks mean healthy animals and plants, as well as happy and healthy humans. Just as we care for ourselves, we must also care for the waterways that we live near.

ACTIVITY

Discuss the responsibilities of a StreamTeam with your class to determine if this is an on-going activity they would like to be involved in.

1. **Why is it important for people to keep streams clean, to preserve and enhance them?**
   (animals, fish and plants need clean water for living, we need clean water for drinking, recreation, agriculture, etc.)
2. **List several problems that might exist in and around waterways near your school.**
   (garbage, oil slicks, eroded stream banks, lots of weeds, etc).
3. **What are actions we can take to help reduce these problems?**
   (pick up trash, stencil storm drains, pull weeds.)

See accompanying student worksheet.

STREAMTEAM RESPONSIBILITIES

If your class chooses to form a StreamTeam, they will adopt a section of stream or other body of water near the school to keep clean, monitor and protect. Adopting a waterway will give your students a sense of satisfaction and pride for their hard work; it will be a fun and educational outdoor experience; and it will help them understand their connection to the natural environment.

THE RESPONSIBILITIES OF A SCHOOL STREAMTEAM INCLUDE:

1. Identifying the waterway near your school.
2. Signing an agreement with the city about the work you will do on the adopted waterway.
3. Creating a watershed map.
4. Planning a creek walk to take inventory of your adopted waterway — find out where pollution problems are, soil erosion, urban development impacts.
5. Setting Priorities:
   storm drain marking
   monthly creek cleanups
   plant native tree/plant species
   pull non-native plants
   other ideas
6. Ongoing activities: visually monitor stream weekly and look for changes in water or vegetative health; report spills; encourage students to keep school yard, sidewalks and the street in front of the school free of oil spots, loose trash, pet waste, etc.

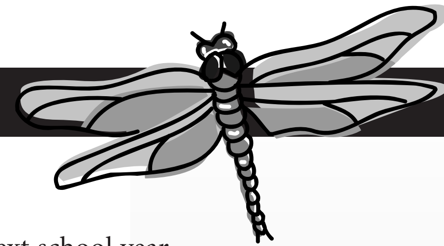
To help your students become familiar with their adopted waterway, several activities have been selected to enhance your StreamTeam experiences.

Mapping Your Watershed (Activity 2.2)
Adopt-A-Waterway (Activity 2.3)
Environmental Networks on the Web (Activity 2.4)
Watershed Walk (Activity 2.5)
Waterway Clean-Up (Activity 2.6)
Storm Drain Marking (Activity 2.7)

PEOPLE TO CONTACT

WASH Education Program 303-413-7365

STUDENTWORKSHEET2.1



STREAMTEAM CHECK-OFF LIST

Check off each activity your class does for your adopted waterbody over the next school year

Activity	✔	Date(s) Completed	Actions Taken
Map Watershed			
Inventory Creek			
Storm Drain Marking			
Watershed/waterway Cleanup (to be done 4 times/year)			
Non-Native Plant Pull			
Water Quality Monitoring			
Biological Monitoring—Bugs Count (to be done 1 to 2 times/year)			
Other			

ACTIVITY 2.2
MAPPING YOUR WATERSHED

GRADES **4-12**
TIME **one** class period

SCIENCE STANDARDS

#4.3 Students know major sources of water, its uses, importance, and cyclic patterns of movement throughout the environment.
#5 Students know and understand ways science, technology, and human activity can affect the work and its resources.

OBJECTIVE

The students will……

- gain an understanding of the watershed boundary surrounding their adopted waterway, and
- step-by-step, go through the process of finding the waterway you near your school to study, locating the watershed, and mapping it onto a large piece of paper that will be hung in your classroom as the central orienting framework for the work your class does on their adopted section of creek..

BACKGROUND

When asked to define who we are, we often will say where we are from. In order to understand ourselves, it is important that we understand the place we live. This mapping exercise will provide students with the opportunity to become familiar with the watershed that the school is located in.

WATERSHED DEFINITION

A watershed is an area of land in which all rain and snow runoff and small tributaries drain into a common body of water such as a creek or lake.

The size of a watershed can vary from the land that surrounds and drains into Bear Canyon Creek in South Boulder, to the Mississippi River Basin which collects water from lands to the east and west of the river. The Mississippi River watershed is composed of several thousand smaller watersheds, including the Boulder and St. Vrain Creek watersheds, which eventually contributes water to the Mississippi.

Watersheds are a unique framework from which to study water resources issues. Everything that occurs in the watershed affects both the land and the water. By focusing on small, local watersheds like Boulder and St. Vrain Creek, we can bring the focus of water quality and quantity issues, which are impacted and affected by the people of Boulder County region, to them, and provide a framework from which relevant management and action can be taken.

FACT:

The Continental Divide is the largest drainage divide in the U.S. All waters that fall to the west of the divide flow to the Pacific Ocean. All waters that flow to the Atlantic Ocean fall on the east side of the divide.

2 Activity Level

Q:

Can your class trace the route that water must travel from the class' adopted waterbody, to Boulder Creek and finally to the Mississippi River?

You may want to laminate your map and then use a wax pencil to outline the drainage divides surrounding your watershed.

You may want to have a discussion about land use (development, agriculture, open space, industry and its affects on the watershed.

MATERIALS

- City/county road maps, topographic maps
- Pencils, Crayons
- Compasses, Rulers
- Poster Paper: to draw watershed of adopted waterbody

ACTIVITY

1. Look at a city map and find out what body of water (creek, wetland, pond) is near your school.

2. Next, look at a topographic map and see if you can locate the creek or pond on that map (often times topographic maps will have major streets and other landmarks).

3. Once you locate the creek or pond, mark where your school is on the map (this will help keep everyone oriented). Also measure out on the map the section that you will adopt—this will be the section of creek that you will clean-up, monitor for pollution contamination, watch for wildlife, etc. It can be anywhere from 2 blocks to 1/4 mile long; whatever seems reasonable to your class.

4. Look at the topographic map. Can you find the contours lines on it? These lines show the elevation of the landscape. To locate the watershed that your creeks drains, look for the highest ridges or hills around your stream—these are the drainage divides. Drainage divides separate one watershed from another.

5. Once you have outlined the shape of the watershed—have students locate well-known places such as the school, parks, bike paths, the grocery store, etc. Students may also locate storm drains in the vicinity of their school.

6. Determine the direction of water flow (draw blue arrows from the landscape to the water). Which direction does the water flow? Are there any storm drains present that might intercept water as it funnels into the streets?

7. If you are looking at a stream in an urban environment, sometimes the stream may disappear—it may be piped underground. Contact your local government for maps of the storm sewer system. When water enters the storm sewer system, where does it go? Is this water treated? Mark the direction of flow, with arrows, toward local creeks from the storm drains. This will give you information about water supply system in your watershed. Are there ditches connected with your stream? Find out the history of irrigation ditches in your community.

EXTENSION

Build a relief model of your watershed out of paper mache.
Related Project WET Activities Include:
Color Me A Watershed (223-231)
Rainy-Day-Hike (186-190)
Branching Out! (129-132)
A-maze-ing Water (219-222)
Just Passing Through (166-170)

PEOPLE TO CONTACT:

WASH Education Program 303-413-7365

REFERENCES:

Hands on Save our Streams. Izaak Walton League. September 1995.

GRADES **4-12**
TIME **see** below

ACTIVITY 2.3
ADOPT-A-WATERWAY

SCIENCE STANDARDS

#1 Students understand the processes of scientific investigation and are able to design, conduct, communicate about and evaluate such investigations.

#5 Students know and understand ways science, technology, and human activity can affect the work and its resources.

Time required

30 minutes on three separate days

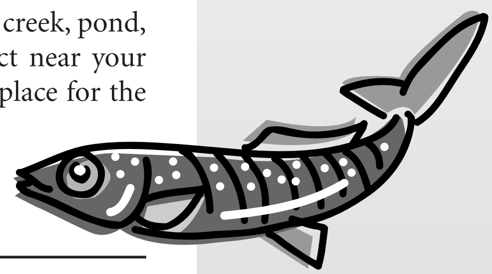
OBJECTIVE

The students will…

- explore the waterway near their school through researching the history of the waterway they adopt.

BACKGROUND

There are many places, even in the city, where wild animals and plants live. These urban ecosystems need our help to stay clean and healthy. By adopting a creek, pond, wetland or ditch near your school, and/or storm drain marking project near your school, your classroom StreamTeam will be helping to take care of that place for the animals and plants that live there and for your enjoyment.



ACTIVITY

Write the word "adopt" on the chalkboard. Discuss with students the meaning of the word and where the students have seen the term. Repeat the process with the words "creek, wetland, and pond." Discuss the differences between these bodies of water. Which one best describes the waterway near your school? Encourage students to share their experiences with this waterway. Organize the students into cooperative groups of four with each group responsible for reporting on a certain aspect of the class' adopted waterway. Provide time for the groups to research one of the assigned or selected activities from the following list:

1. Find out where the name for your waterway came from.

2. Where does your waterway begin and end; or where does water enter and leave your wetland or pond?

3. Find out if anyone "owns" your waterway.

4. How is the water used by people?

5. Observe what plant life relies on the water in your adopted waterway. Encourage students to draw pictures of plant life associated with the waterway.

6. Discover what animal life relies on the water in your waterway. What signs of animal life can your students observe there?

7. Visit your adopted waterway during different seasons of the year. Write about the changes and similarities they observe. Document your visits by taking pictures and hanging them in your classroom.

8. How is the water quality of your adopted waterway affected by the urban setting? What are some things your class could do to help maintain or improve the quality of the water?

9. Discuss why the waterway might be dangerous. Discuss how one should behave safely around it.

Encourage each student to report to the other students the results of their research. The pictures, drawing, and photographs should become part of a wall mural entitled "Adopt-a-Waterway."

PEOPLE TO CONTACT

WASH Education Program 303-413-7365

PLACES TO LOOK

1. Boulder Public Library
2. Carnegie Historic Library
3. Your local library

ACTIVITY 2.4
ENVIRONMENTAL NETWORKS ON THE WEB

GRADES **4-12**
TIME **30-50** minutes

SCIENCE STANDARDS

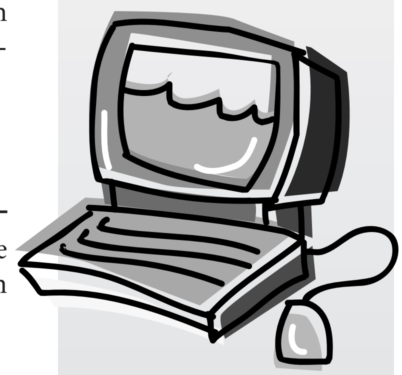
#7 Students know how to appropriately select and safely and effectively use tools (including laboratory materials, equipment and electronic resources) to conduct scientific investigations.

OBJECTIVE

The students will
- search the Internet for watershed and stormwater projects, and
- become familiar with searching for water-related information on the Web. The The activity will serve as an introduction to the Internet for students not familiar with its capabilities, as well as helping to expand their knowledge of the type of information they can access.

BACKGROUND

Communication about local environmental issues is becoming increasingly possible through the Internet. Students will be asked to research watershed activities going on at other locations and develop an outline for their own web-page.



ACTIVITY #1

Create access to computers for students. Students should work in pairs, and record information, addresses, and formats that they think would be applicable to setting up their own web site for this unit.

See accompanying student worksheet.

The following sites serve as places to get started:

www.basin.org
(water information for Boulder County)

http://waterknowledge.colostate.edu/default.htm
Colorado State, Colorado Water Knowledge

http://www.epa.gov/water/kids.html
EPA. Water For Kids

http://ga.water.usgs.gov/edu/
USGS Water Science for Schools

http://www.ci.austin.tx.us/watershed/education.htm
(Austin, TX watershed education program information)

http://www.city.palo-alto.ca.us/cleanbay/school.html
(City of Palo Alto, CA water education program information)

2 Activity Level

http://www.coloradowater.org/cwa_main.asp
(Colorado Watershed Assembly)

http://www.enviroscapes.com/index.html
(watershed education kit/tool)

http://www.uwex.edu/erc/gwah/index.html
(free online watershed activity guide)

http://www.epa.gov/adopt/patch/patchprogram.pdf
(EPA's Water Drop Patch Project – includes storm drain marking guidelines)

http://www.stormwatercenter.net/
(Center for Watershed Protection)

http://www.sacstormwater.org/fun/kids.htm
(The City of Sacramento Stormwater – Stormwater Kids Page)

http://www.forester.net/sw_0209_grassroots.html
(Stormwater Programs & Public Involvement)

http://www.bayeducation.net/lessons.html
(ChesSIE Teaching Resources)

http://globe.fsl.noaa.gov http://globe.fsl.noaa.gov/fsl/welcome/welcomeobject.pl
(The above web site links to the Globe site)

http://danenet.wicip.org/ywen/index.html
(watershed education networkin Wisconsin)

http://www.springsgov.com/Page.asp?NavID=128
(Colorado Springs stormwater/watershed page)

To gauge the level of Internet understanding acquired by each student, ask students to complete the following worksheet.

ACTIVITY #2

Create Your Own Web Page!!
It is possible to start their own web-page, and communicate with other schools in the Boulder Creek watershed and Boulder County watersheds, as well as classrooms and watershed groups world-wide. For assistance in creating a StreamTeam web page contact the WASH Education Program.

PEOPLE TO CONTACT

WASH Education Program 303-413-7365

STUDENTWORKSHEET2.4

ENVIRONMENTAL NETWORKS ON THE WEB

Location	Web Address	Purpose

1. Identify three watershed projects and, briefly, describe each one.

2. List one (or more) aspect of the above projects that you find interesting and may want to incorporate as part of this class.

3. Write a one paragraph narrative that you would want to send one of the watershed or stormwater projects above (for example: questions, description of our project, ideas, etc.)

ACTIVITY 2.5
WATERSHED WALK

GRADES **4-12**
TIME **45-120** minutes

SCIENCE STANDARDS

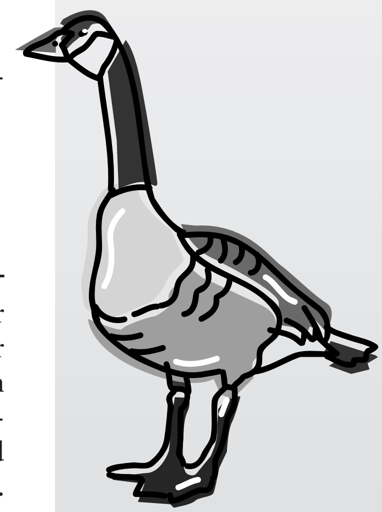
#1 Students understand the processes of scientific investigation and are able to design, conduct, communicate about and evaluate such investigations.

#3 Students know and understand the characteristics, structures, processes, and relationships of organisms and how they may be affected by environmental changes and the passages of time.

#5 Students know and evaluate interrelationships among science, technology, and human activity and how they can affect the world.

OBJECTIVE

The students will…
- walk and observe the riparian environment around their adopted waterway,
- visually assess the waterway that they have adopted by filling out the Watershed survey, and
- compare and revise their watersheds maps with the real environment.



BACKGROUND

The outdoors offers a variety of learning opportunities. If students have mapped their watershed, have them bring their maps along to compare. If not, it is important for students to observe the watershed from a “holistic” perspective (Adopt-A-Stream Foundation, 1996). A holistic approach means observing the land features (i.e., elevation of the landscape), land use (buildings, storm drains, etc.), the creek’s physical and biological characteristics, and any other features that may affect the watershed balance.

TEACHER PREPARATION

The week before
1. Walk the study area of the watershed before your class outing to note any dangerous areas, and the location of private property. If students need to walk on private land, visit the landowner to get permission before the walk.
2. Locate storm drains near the watershed area of study to determine direction of flow toward local creek(s).
3. Send home permission slips.
4. Find parent helpers.

2 Activity Level

See accompanying student worksheet.

THE DAY BEFORE

1. Make sure all students have signed permission forms.
2. Remind students to wear appropriate shoes and clothing.
3. Review safety issues.
4. Discuss purpose of the walk.
5. Divide students into teams of five; choosing 2 team leaders per group. One leader can be responsible for recording observations from the group on the worksheet and the other can record major landmarks on a watershed map.
6. Discuss and review key words found on worksheet.

PEOPLE TO CONTACT

WASH Education Program 303-413-7365

REFERENCES

Hands on Save Our Streams. Karen Firehock. Izaak Walton League of America, Inc. September 1995.

Streamkeeper's Field Guide. Adopt-A-Watershed Foundation. 1996.

Activity Level 2

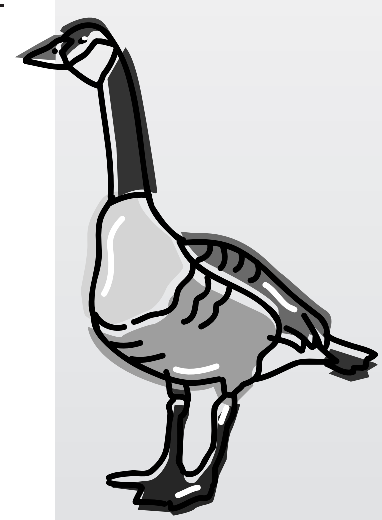
STUDENT WORKSHEET 2.5
WATERSHED WALK

Team Names ____

Date ____________

During your walk, you will observe the watershed (the area surrounding your adopted waterway) and the riparian zone of your adopted waterway. Make observation notes on your worksheet and on your watershed map where appropriate.

WATERSHED SURVEY QUESTIONS



While you walk along the waterway answer the following questions:

Describe the Land Uses

1. Check off the land uses in the area:

___ roads ___ houses ___apartments ___shopping malls ___ schools

___ parks ___ open space ___ animal pastures ___ farms

___ golf courses ___ sewer covers

___ landfills/trash dumps r ___ stormwater drains

Mark primary locations on your watershed map.

2. What percentage of the watershed is open lands (park, lawns, golf courses, open space, other)?

3. What percentage of the watershed is developed?

4. What are the main vegetation types in the watershed?

5. Where does rain go when it falls? Are there many areas where rainwater can soak into the soil or does it run off paved areas?

6. Find a storm drain and draw a picture of it. Mark storm drains on your map.

7. What are storm drains for? Where does water go after it flows into the storm water drains?

8. Do you see trash in the streets? What happens to the trash when it rains?

WATERWAY SURVEY QUESTIONS

Describe the Stream/Pond/Wetland:

1. What are the major land uses directly bordering your waterway?

2. Do you see any outfall pipes along the banks that might discharge water into it?

3. What are the pipes made of?

___ metal? ___ concrete? ___ plastic?

4. Do you know where they are coming from?

5. What impacts might this outfall pipe have on your waterway?

6. Is the waterway natural or has it been changed or even made by people?

7. Mark the following characteristics that best describe your waterway:

___ channeled ___ dirt and vegetation on streambanks

___ riffles and pools ___ rocks on the bottom ___ concrete sides

___ stone walls ___ concrete bottom

8. Describe the vegetation that is growing on the banks.

9. Do you see trash in the water? Describe what kind of trash you see.

FACT:

All storm drains collect rainfall and snowmelt runoff from streets, sidewalks, building tops and lawns. Storm drains carry this excess water to the nearest waterway.

2 Activity Level

10. Do you smell any unusual odors or does the water have any strange colors? Describe the smells and colors.

11. Do you see signs of animal life in or around your adopted waterway? Draw pictures of the animals or their tracks you may see.

12. Do you see animal houses such as beaver dams, bird nests, squirrel holes? What is another name for the place an animal lives?

13. List the animals, birds, and other wildlife you see on your walk.

14. Can you see fish in the water? How many? How big are they? Can you name the species?

15. Do you see or hear insects? What do you see or hear?

ACTIVITY 2.6

WATERWAY CLEAN-UP A TREASURE HUNT

GRADES **4-12**
TIME **see** below

SCIENCE STANDARDS

#1 Students understand the processes of scientific investigation and are able to design, conduct, communicate about and evaluate such investigations.

#5 Students know and understand interrelationships among science, technology, and human activity and how they can affect the world.

Time required

one class period—four times a year

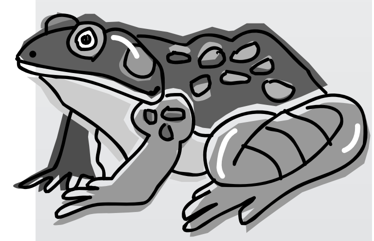
OBJECTIVE

Students will…

- conduct a waterway clean-up through a treasure hunt activity,
- allow students to take responsibility for the place they live and gives them a strong sense of satisfaction, and
- discuss their post-treasure hunt findings.

BACKGROUND

If you look around you will notice plastic cups, newspapers and soda cans collected around storm drains, blown into corners of buildings, parking lots and school yards, and in and around waterways. If we are to have a clean environment, sometimes it means that we have to do our part. This activity gives instructions for organizing a clean-up in and around your adopted waterway.



ACTIVITY:

This activity should be done at least 4 times during the school year.

The Week Before:

1. Scout out the area your students will be cleaning up to define the clean-up boundaries and to become familiar with the area.
2. Give students permission forms to take home to parents.
3. Get trash bags from the WASH education Program.
4. Find parent helpers.

The Day Before

1. Make sure everyone has signed permission slips.
2. Divide students into teams of 3 (assign one student to write down items they find for the scavenger hunt).
3. Review purpose of the Clean-up Treasure Hunt. Explain that they will be cleaning up the watershed and the waterway that your class has adopted. Clean-ups are a very important way of maintaining and improving water quality and habitat.
4. Remind students to bring a pair of work gloves to school for the clean-up.

See accompanying student worksheet.

2 Activity Level

Clean-up Day

1. Pass out scavenger hunt and discuss it.
2. Pass out 2 plastic garbage bags per group. In one, they should put recyclable items, in the other trash.
3. Remind students to be careful when picking up broken glass. Tell them they should not pick up anything that looks dangerous or harmful.

After Clean-up Discussion

1. Discuss what "trashy treasures" students found on the clean-up.
2. Ask students how they felt about the clean-up activity.

Did they like it?

What did they find out about the area around the waterway?

What are some things they can do to help reduce the amount of trash found in the watershed and in/near the water?

PEOPLE TO CONTACT

WASH Education Program 303-413-7365

STUDENTWORKSHEET2.6
TRASHY TREASURE HUNT

Student Names ____

Date _____________

While you clean up waterway that your class has adopted, keep a look out for the following things (be sure to collect all items in your garbage bags and dispose of properly at the end of the clean-up):

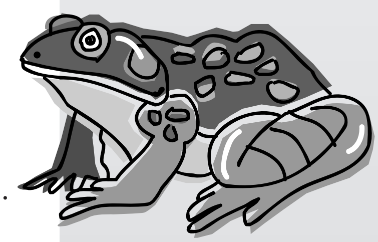
1. A newspaper from the month that you are doing the clean up (i.e., if it is March, see if you can collect a newspaper that is from March)

2. Something that can be used again.

3. Something that has begun to decompose or break down.

4. Something broken.

5. Something that you are sure no one else will find (the most unique piece of trash).



6. Something round.

7. Something recyclable.

8. A wrapper or container from a fast food restaurant.

9. Debris or trash near a storm drain.

2 Activity Level

WatershED
Activity 2.6

ACTIVITY 2.7

STORM DRAIN MARKING

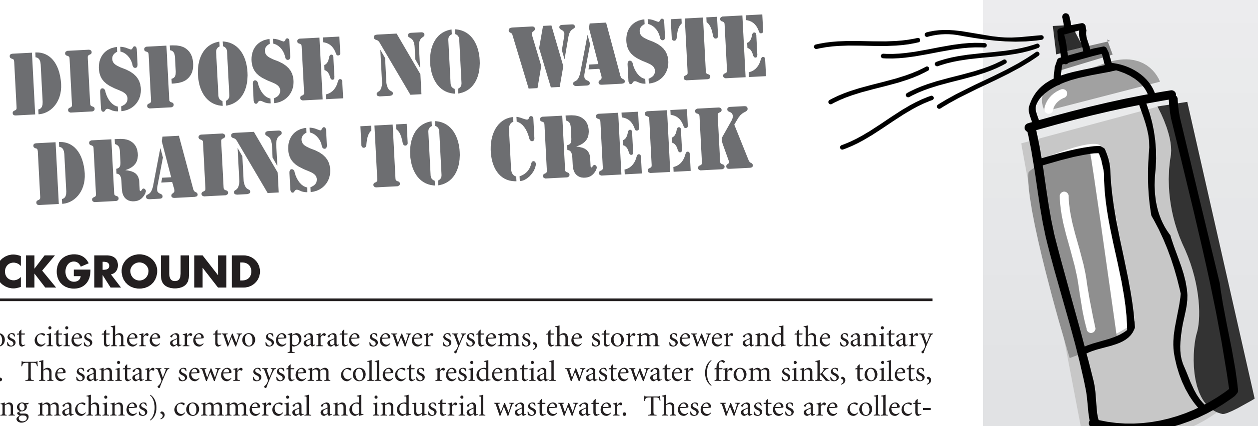
GRADES **4-12**
TIME **1-2** class periods

SCIENCE STANDARDS

#5 Students know and understand interrelationships among science, technology, and human activity and how they can affect the world.

OBJECTIVE

Students will…
- mark the message: "Dispose no Waste, Drains to Creek," on curbs above storm drains, and
- distribute and/or create and distribute fact sheets or flyers, that communicate the fact that storm drains are connected to creeks, in the vicinity of their storm drain marking activity.



BACKGROUND

In most cities there are two separate sewer systems, the storm sewer and the sanitary sewer. The sanitary sewer system collects residential wastewater (from sinks, toilets, washing machines), commercial and industrial wastewater. These wastes are collected and delivered to the wastewater treatment plant.

The storm sewer system is made up of a network of pipes that connect gutters and storm drains to nearby waterways. As rain and melting snow flows over streets, roofs, and parking lots, water may collect pollutants such as litter, pesticides, heavy metals and oil. The runoff water is then collected in the storm sewer system and flows directly to the stream with little if no treatment.

Because both sewer systems discharge waters to the natural environment, care must be taken to prevent or minimize disposal of hazardous wastes into these systems.

MATERIALS

All of the below listed materials will be provided by the WASH Education Program

markers with the message "dispose no waste"	spray paint	traffic cones	eye wash
	stencils	tape	glue
	wire brushes	newspaper	
	orange vests	protective gloves	

Activity Level 2

ACTIVITY

Two Weeks Before

Call the WASH Education Office for information and to arrange drop off of Storm Drain Marking kits.

One Week Before

1. Send permission/risk and release forms home for parents to sign.
2. Find parents to help with outing.
3. The following activities are good pre-stenciling activities that will increase connections to the purpose of stenciling and offer additional background information:

Enviroscape: Call 303-413-7365 to perform this activity with your students in the classroom.

See accompanying permission risk/release form.

Project WET: Rainy-Day-Hike (186-190)
Branching Out! (129-132)
A-maze-ing Water (219-222)
Just Passing Through (166-170)

Day Before

1. Divide students into groups of five. Discuss duties (allow students to rotate, to give everyone a chance to spray paint):
 (2) safety officers — wear orange vests and set out traffic cones
 (1) to brush off side walk and to tape down stencil
 (1) to spray paint stencil
 (1) to hang fish-shaped informational door hangers on house in the neighborhood.
2. Make sure everyone has a signed permission slip.
3. Remind everyone to wear old clothes.
4. Call the media (optional) to report that your students are conducting a community project.
5. Ask the following questions as a warm-up activity:

What does it look like deep below that metal grate?

What kind of stuff goes in there?

Where does the dark drain lead to?

Are there any activities that we do that may wind up in the drains?

What pesticides, washing our cars, etc.? Do these substances go into the storm drains?

Who lives near the creek that might be affected by this?

What can you do, besides storm drain marking, to make your community, family, school, etc. aware that waste in the storm drains flow directly to the creeks and prevent it from happening? [if you see oil in the driveway, soak it up with kitty litter; use a pooper scooper or baggie and throw the pet waste into the trash; don't use pesticides, weed killers, herbicides – especially if rain is in the forecast; etc.]

2 Activity Level

Day of the Marking Project

1. Go over stenciling instructions once more
2. Give students copies of the map of the area where they are to stencil.

After stenciling, return kits to WASH Education Office with a map of where you stenciled.

EXTENSION:

Students may create their own flyers to distribute in the vicinity of their stenciling neighborhood. This task will create a greater connection and understanding or storm sewer systems and their discharge to local creeks. The following web site offers examples of flyers that students can make:
http://www.ci.austin.tx.us/watershed/stormdrain_edu.htm

PEOPLE TO CONTACT

WASH Education Program 303-413-7365

ACTIVITY 2.8

STORM DRAIN MARKING ACTIVITY (SDSA)
ADVISEMENT OF RISK AND RELEASE

Please read this form carefully and be aware in registering your child or ward for participation in this activity you will be acknowledging the risk and releasing all claims which you may have or have on behalf of your child/ward as a result of participating in this activity.

I give permission for my child/ward to fully participate in the storm drain stenciling activity being conducted in Boulder County, Colorado. In the SDSA, despite preparation, instruction, medical advice, conditioning, and equipment, there is still a risk of injuries from participation including exposure to paint fumes, chemicals, open storm drains, street traffic, automobiles, garbage, debris, etc.

As a parent/guardian of a participant in this activity, I acknowledge that there are risks of injury and I agree to assume those risks which my child/ward may sustain as a result of participating in any and all activities connected with or associated with the storm drain stenciling activity.

I release all claims which may arise against, and I agree not to sue the city of Boulder and its officers, agents, employees and authorized volunteers, on my behalf or on the behalf of my minor child/ward as a result of participating in the storm drain stenciling activity.

I further agree to indemnify, hold harmless and defend the city of Boulder and its officers, agents, employees and authorized volunteers from any and all claims by other parties resulting from injuries, damages, and losses caused by me or my minor child/ward arising out of, connected with, or in any way associated with the activities of the SDSA.

In the event of any emergency, I authorize city officials to secure from any licensed hospital, physician, and/or medical personnel any treatment deemed necessary for my minor child's immediate care and agree that I will be responsible for the payment of any and all medical services rendered.

I also give permission for media coverage of myself and/or my minor child/ward to be disseminated for public relations purposes.

I have read and fully understand the above. I understand this agreement shall not be modified orally.

Child's Name ____ Date _________________

please print

Parent/Guardian Signature ____

Address ____

Phone ____________________________________

Activity Level 2

D

WatershED

Boulder Creek/
St. Vrain
Watershed
Education

LEVEL
THREE
ACTIVITIES

Activity Level 3

ACTIVITY 3.1

WATER QUALITY MONITORING:
A SNAP-SHOT IN TIME

GRADES 6 -12
TIME 40-70 minutes

SCIENCE STANDARDS

#4.3 Students know major sources of water, its uses, importance, and cyclic patterns of movement throughout the environment.

#5 Students know and understand ways science, technology, and human activity can affect the work and its resources.

#7 Students know how to appropriately select and safely and effectively use tools (including laboratory materials, equipment and electronic resources) to conduct scientific investigations.

OBJECTIVE

Students will….

- monitor water quality to understand the health of their waterway, its potential for aquatic organisms, and changes over time.

Note: Call 303-413-7365 to reserve the Water Quality Testing Kit.

BACKGROUND

The Boulder Creek/St. Vrain watersheds are comprised of hundreds of tributaries, numerous wetlands, lakes, and reservoirs. Select an appropriate water body for monitoring. You can monitor more than one station, or at least put your data on the Boulder Creek web page so other classes can see your results. For example, you can monitor for potential differences in water quality upstream and downstream of stormwater outfalls.

Just as we test our blood to monitor our body's health, so must we test the waters to evaluate the health of the land. Our rivers, streams, and wetlands are the arteries that provide essential functions of our ecosystem. Scientists, cities, and citizens use water testing as an indicator of how much life a stream may support, to determine if pollution is effecting the waterway, and how seasonal effects may change water quality. Many of the waterways are linked with groundwater that is often used for drinking water supplies. Unfortunately, it is financially impossible for government agencies to monitor every waterway in the state. It is up to citizens (including this class) to observe their local water, and records developed as part of this assignment will be used to evaluate environmental health.

MATERIALS

Water Quality Testing Kit (call 303-413-7365 to reserve your kit)
Streamkeepers Field Guide
Sample bottles
Sample labels
Journals
Camera

ACTIVITY

Pre-lab
After explaining basic concepts (such as nutrients, hydrology, etc.) have students write down in their journals three questions that they want answered as part of the field trip. This activity will also enable a hands-on testing approach to water quality effects from non-point source pollution.

Students can analyze the water either in the field or back at school.
In addition to collecting water samples, make sure they record observations of plant life, animals, water level, weather, and so on.

Students work in groups to measure various water quality parameters. This is an inquiry-based activity, there are no pre-determined answers. Students must work within their class community to obtain relevant information and develop a description of waterway health

Water quality sampling can take anywhere from 25 minutes to over an hour (this does not include the amount of time necessary to get to and from your site). In order to minimize the time sampling and analyzing the samples it is suggested that the class be broken up into three groups.

The following parameters can be evaluated:
• pH • Nitrogen • Hardness • Temperature • Ammonia
• Phosphorous • Dissolved Oxygen • Turbidity

Additionally, depending on available materials it may be possible to monitor for additional parameters.

GETTING STARTED

(1) At least two weeks ahead of time: Contact the WASH Education Program to reserve a water quality kit and additional resources.
(2) Review Background information in the Streamkeeper's Field Guide (Chapter 7.)
(3) Divide the class into three groups and assign them their activities. Each group should record their data on the provided data sheets (included in the Water Quality Kit). Other observations, drawings, photographs, etc. should be recorded in their journals. The data sheets can be copied by students at a later date into their journals.

WATER QUALITY ISSUES

Water quality varies seasonally and is influenced by human activities throughout its watershed. Visit the Streamkeeper's Field Guide (Chapter 7) for information on specific water quality parameters.

ON THE WEB

If the waterway is a relatively large stream (Boulder Creek, St. Vrain River, etc.) daily discharge numbers can be obtained through the USGS:
http://waterdata.usgs.gov/co/nwis/rt ; if not, you may have to set up your own stream gauge (see activity 3.5)

ADDITIONAL INFORMATION

Water quality monitoring is often termed a "snapshot" evaluation of the waterway's health, meaning that it can only provide information relevant to conditions measured at the time of sampling. Therefore, it is advisable to monitor the waterway over several intervals, and to compile previous data for future comparisons. Additionally, cooperation with other schools, and government agencies can often expand the data.

Another means of evaluating the waterway's health is to look at the health, type, and number of organisms living in the waterway. Macroinvertebrates are easily to collect, and provide long-term indications of the waterways health. See activity 3.3 (Macroinvertebrate Lab) for more information.

Students can be required to compile a final report on the waterway, and thus, detailed accounts of all activities in their journal will be necessary for documentation.

EXTENSION

Explore a hands-on, inquiry-based water quality investigation based on research questions that you and your class decide to explore. Tie in relationships to all previous activities and community projects (StreamTeam, storm drain marking, etc.).

Example research questions include:

1. Is the water quality the same above and below your community?

2. Is the water quality the same above and below a mining site?

3. Do the water quality parameters indicate creek health?

4. Is there enough biological diversity to indicate a healthy creek (may be best after activity 3.3)?

5. Is there a difference in water quality before and after a major rainstorm?

Q:

How does nitrogen in the precipitation lower the pH?

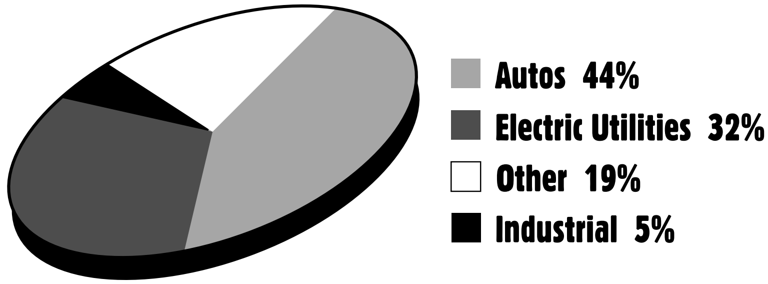
When do you expect the organisms in the streams to be the most sensitive to water quality changes?

What factors influence pH?

What types of pH is healthy for aquatic organisms?

Why is DO an important parameter?

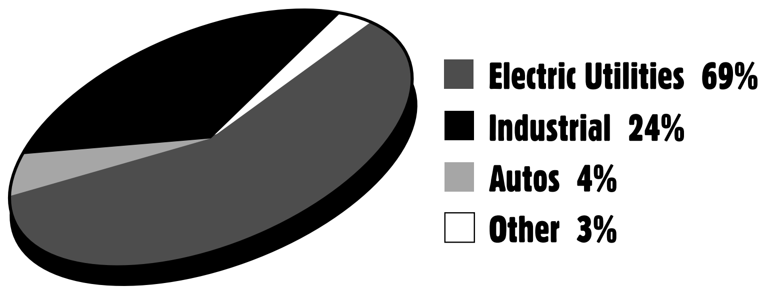
Alkalinity is a measure of the buffering capacity. Why is it an important variable?



U.S. NOx Emissions (1992, 23.2 Million Tons)

How did each group report to the class?

How is this analogous to how scientists work?



U.S. SO_2 Emissions (1992, 22.7 Million Tons)

PEOPLE TO CONTACT

WASH Education Program 303-413-7365
Colorado Division of Wildlife, River Watch Coordinator 303-291-7388
SVVSD Science Coordinator 303-682-7246

ACTIVITY 3.2

NUTRIENTS: BUILDING ECOSYSTEMS IN A BOTTLE

GRADES **5 - 12**
TIME **40-70** minutes

SCIENCE STANDARDS

#4.3 Students know and understand major sources of water, its uses and importance, and its cyclic patterns of movement through the environment.

#5 Students know and understand ways science, technology, and human activity can affect the work and its resources.

OBJECTIVE

Students will…
- collect pond water samples containing algae to learn about the nutrient cycle and how nutrients affect water quality and the aquatic ecosystem, and
- be given the opportunity to develop hypothesis and verify their hypothesis.

BACKGROUND

Growth of all organisms is dependent on receiving sufficient nutrients. The primary nutrients are carbon, nitrogen, and phosphorous. We receive our nutrients from the plants and other animals we consume. Plants also depend on these nutrients. Because of the relative abundance of carbon dioxide in the atmosphere, carbon is generally not a nutrient that limits plant growth. In rivers, lakes, and ponds phytoplankton and other plants are generally limited by the amount of nitrogen and phosphorous found in the water. The ratio of nitrogen to phosphorous in the water indicates which nutrient will be the limiting nutrient. N: P ratios are generally greater than 10, and thus are phosphorous limited.

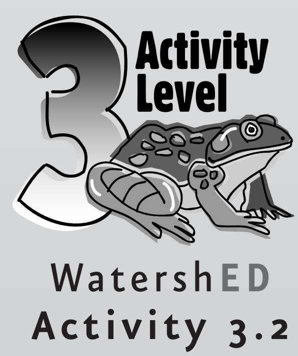
Because lakes are generally phosphorous limited, a number of detergents, fertilizers, etc. have been blamed for the eutrophication of lakes and streams. Most detergents today are labeled as being phosphorous free due to industry attempts to rectify eutrophication problems.

MATERIALS

several clear plastic bottles or baby food jars
$NaNO_3$ and $NaPO_4$ (or fertilizer can be used)

FACT:

High numbers of blue-green algae relative to the number of desmids and diatoms indicate the pond is eutrophic. An eutrophic pond generally indicates that high amounts of nutrients are entering the lake. This can be natural, from runoff over feedlots, runoff from fertilizers, sewage input, etc.



FACT:

The number and type of plankton present will also depend on the time of year. During the winter when the sun's rays are low, there is generally a lack of photosynthesizing plankton.

ACTIVITY (GRADES 6-12)

Collect pond water that contains algae from your local pond. This water can then be placed in different beakers or jars with different concentrations of nitrogen and phosphorous added.

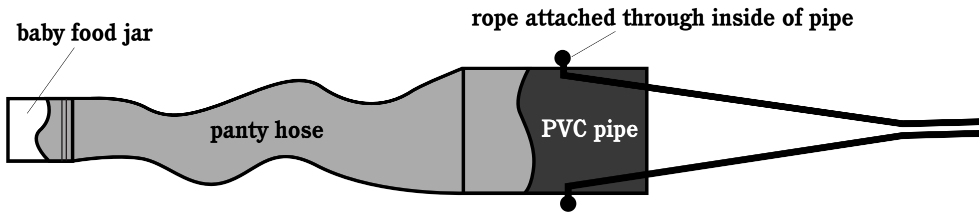
Jar#	Nitrogen Concentration	Phosphorus Concentration	Observations
Control	0	0	
#1	0.1M	0	
#2	1M	0	
#3	0	0.1M	
#4	0	1M	
#5	1M	1M	

M = moles per liter This is qualitative—measure in "drops" added

The above table illustrates how to set up a matrix to test the effect of different concentrations of nitrogen and phosphorous on algal growth. Growth will take around one week or more and can be measured visually, or by using a spectrophotometer.

Record your results after one week and discuss how surface water runoff could effect the color, smell, and vitality of neighborhood lakes, streams, and ponds.
Primary sources of external nutrients are:

1. Municipal wastes
2. Industrial wastes
3. Agricultural runoff
4. Forest runoff
5. Urban stormwater runoff
6. Atmospheric fallout



Plankton Net

Activity Level 3

ACTIVITY #2: BOTTLE ECOSYSTEM (GRADES 4-12)

Another activity that is more applicable to younger students, or those that are not familiar with basic chemistry, is to have students collect their own ecosystem in a 1 liter plastic bottle.

Visit your local creek, pond, or wetland and have students collect their ecosystem. They should fill the bottle about 1/3 with sediments, about another 1/3 with pond water, and leave the rest for air. Make sure they get some aquatic vegetation into their "bottle ecosystem." Cap the bottle tightly, and let is sit under a grow lamp or on the window sill where they can watch the changes. Changes should be monitored over weeks.

The bottle should progress from short-term health, to decay, to balanced equilibrium as the nutrients in the bottle ecosystem (carbon, nitrogen, and phosphorous) reach a balanced point. Have students keep daily notes on the changes occurring in the bottle.

Some bottle ecosystems will not reach this point, and the water will remain discolored, the plants will die, and the water will smell strongly of hydrogen sulfide as the biota decays. The system is "dead." Often these are the systems with too much sediment, minnows (that die and decay), and insufficient air. Some systems will have the right balance, and will reach a balance where the water clears up, the plants prosper, and the system is "healthy."

EXTENSIONS

Have students check for phosphorous content in their household detergents, soaps, etc.

Visit your local streams and note the change in algae growth as a function of the seasons. There is usually a late spring bloom, followed by summer decay, and then a fall bloom as falling leaves decay.

Have students evaluate which possible inputs will effect their local water body.

Have students maintain a log of their bottle ecosystem. They can record water appearance, smell (a balanced system will not smell like rotten eggs (H_2S), plant growth, etc.

Have them compare their bottle ecosystems with other classmates and draw conclusions.

ACTIVITY 3.3

ASSESSING YOUR WATERWAY:
MACROINVERTEBRATES—
LONG-TERM ECOSYSTEM HEALTH

GRADES
5 -12
TIME
30-70
minutes

SCIENCE STANDARDS

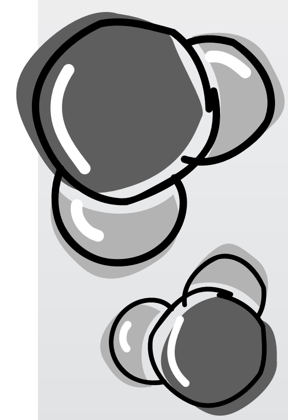
#5 Students know and understand ways science, technology, and human activity can affect the work and its resources.

OBJECTIVE

Students will…
- collect and analyze macroinvertebrates and formulate conclusions regarding riparian habitat.

Note: Call 303-413-7365 to reserve the Bug Investigation Kit.

This activity can be performed either in the field or in the classroom. If time is limited the teacher can collect a limited amount of submerged rocks and aquatic vegetation and bring the habitat to the classroom. You will be amazed at the number of organisms found under just a few rocks!!



BACKGROUND

Macroinvertebrates are the "bugs" found throughout the riparian system and are excellent indicators of the overall health of the system. These "bugs" spend the majority of their lives in the water, sediment, algae, and vegetation around the stream or pond. Some organisms are relatively resistant to pollution and/or variable stream flow, while others are very sensitive to changes in the water quality. By observing what type of species are present in the stream we can get a better understanding of the long-term health of the stream or pond.

Materials included in the Bug Investigation Kit:
buckets
nets
waders or old tennis shoes
ice cube trays/sorting trays
hand lens or microscope
taxonomy charts

3 Activity Level

FACT:

Lake Erie is a well known example of a system that become eutrophic (nutrient rich), algae flourished and then decayed, oxygen levels plummeted, and fish died. The Clean Water act of 1970 mandated secondary wastewater treatment and Lake Erie has made a comeback

ACTIVITY #1: FIELD COLLECTION

Divide the class up into several groups. Provide each group with a net, sorting trays, taxonomy key. Make sure each group has at least one person to record data.

Macroinvertebrates are found throughout the riparian system. The type of organism identified will depend on the flow of the stream section, the amount of gravel substrate, and the overall water quality. Many macroinvertebrates prefer water high in oxygen, and will thus be found in stream sections with plenty of ripples and a gravel substrate.

Samples can be collected in a variety of ways. A common technique is to place the net in the stream and then use a stick, your feet, or hands to stir gravel up-stream from the net. Macroinvertebrates will be dislodged and washed into the net. Empty the net into the sorting tray.

Another method is simply to collect a few submerged rocks, place them in a bucket and return to analyze the substrate back in the classroom. The bottom of the rocks can be scrubbed with a soft dishwashing brush to dislodge macroinvertebrates.

ACTIVITY #2: CLASSROOM ANALYSIS

Specimens can be classified using a variety of taxonomy guides. The Izaak Walton League guide is attached and divides commonly found invertebrates into 3 classifications, depending upon the type of water quality they can tolerate.

For example: mayfly larvae are generally found in good quality water. Leeches may be found in all ranges of water quality, but you would not expect to find mayflies in water that has been severely polluted.

Have the students work in groups of 2-3 for classifying the bugs. Have each group write up a summary of their results, evaluating what type of water quality they think exists, the diversity of organisms, etc.

Classifying water quality based on macroinvertebrates found is simply one more tool to complete the picture regarding the health of your stream.

REFERENCE

Pobst, Dick. Trout Stream Insects. 1990.
Izaak Walton League. Save Our Streams Taxonomy Chart.
Ward, J.V. and B.C. Kondratieff. An Illustrated Guide to the Mountain Stream Insects of Colorado. 1992.

Make sure students are required to record where the sample was collected, what the water looked like, smelled like, etc. in their journals.

FACT:

The types of organisms present will also vary seasonally. Many of the larval stage flies (i.e. mayflies, caddisflies) are abundant in the spring but become less plentiful in the summer and fall months as they have already hatched into their adult phase.

MEASURING DIVERSITY:
THE SEQUENTIAL COMPARISON INDEX

The diversity of organisms is also a potential indicator of stream quality. A simple diversity index, called the Sequential Comparison Index (SCI) can be performed by placing a random sample of invertebrates in a tray and counting the different organisms. Each time a different type of organism is encountered, the student will record this as the start of a new run.

$$\textbf{SCI} = \frac{\textbf{\# of runs}}{\textbf{\# of organisms}}$$

The SCI runs from 0 to 1.0, with 1.0 representing the greatest diversity. You can use the SCI to evaluate water quality.

SCI	Water Quality
0 - 0.30	poor
0.31 - 0.60	fair
0.61 - 1.0	good

For example: You have collected 15 bugs. You identify a sequence of 5 mayflies, and then find a leach, then 4 mayflies, two scuds, a gilled snail, and then 2 more mayflies. Your number of runs is 6.

$$6/15 = 0.40$$

The water quality is fair!!

The advantage of the SCI is you don't have to accurately identify all of the organisms, just whether or not they are different.

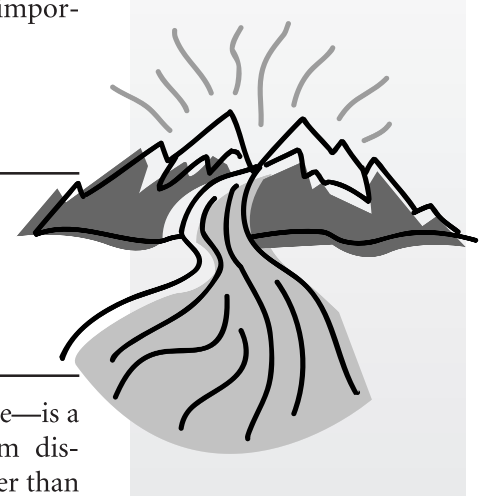
REFERENCE

Pobst, Dick. *Trout Stream Insects.* 1990.
Izaak Walton League. *Save Our Streams Taxonomy Chart.*
Ward, J.V. and B.C. Kondratieff. *An Illustrated Guide to the Mountain Stream Insects of Colorado.* 1992.

ACTIVITY 3.4

STREAM GAUGING: A STUDY OF FLOW

GRADES 6 - 12
TIME 40-70 minutes



SCIENCE STANDARD

#4.3 Students know and understand major sources of water, its uses and importance, and its cyclic patterns of movement through the environment.

OBJECTIVE

The students will…
- measure stream flow.

BACKGROUND

Stream flow—the amount of water moving through the stream per unit of time—is a key parameter when assessing stream conditions. Stream flow—or stream discharge—is generally measured in units of cubic feet per second or m3/s. Higher than normal flows often appear turbid because of material picked up as the stream runs outside its banks. Lower than normal flows can stress riparian flora and fauna.

SAFETY PRECAUTIONS

High water can make stream gauging a potentially hazardous activity, depending on the size of the stream that is being monitored. Scout out the stream before gauging to make sure it is safe.

MATERIALS

yard stick
graph paper
20' of nylon string of rope
tennis balls (sticks can also be used)
net to retrieve the tennis balls
waders or tennis shoes

ACTIVITY

This activity can be conducted in a variety of ways. Stream gauging is a rather intuitive exercise. You measure the cross-section of the stream (m2) and then determine the time it takes for an object (i.e. stick or tennis ball) to move over a measured dis-

3 Activity Level

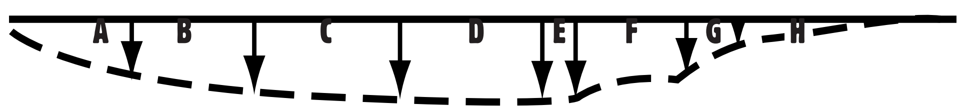
It may be worthwhile to "permanently" fix a yard stick or marked stick so that the flow can be estimated at various times of the year. Find a tree, bridge, or post that will withstand the higher stream flows and affix your gauge to this structure.

This activity is an excellent homework assignment. Students can compare results and come up with an average value.

Discuss the advantages of multiple measurements and how scientists use approximations during all investigations. How could you improve your stream discharge estimate?

tance. Assuming the cross-section determined is relatively consistent over the measured distance:

Cross-sectional area x speed of water = Stream discharge
(m2) (m/s) (m3/s)



Pick a section of the stream that has a fairly uniform flow and a uniform cross-section. Extend a tape measure across the cross-section and have two students hold each end. Another student should measure the depth of the stream at specific distances from one of the stream banks. Record all of the data so the cross-sectional area can be estimated back in the classroom, or as a homework assignment.

AreaA + AreaB + AreaC + ------ = Cross-sectional area of the stream

After the cross-section data has been collected, it is now time to get the velocity of the water moving through your measured cross-section. Measure a distance above the cross-section (i.e. 3 meters). Make sure you pick a distance where the cross-section is relatively uniform. Measure the time it takes for a floating object (such as a stick or tennis ball) to move this distance (m/s).

You now have sufficient data to estimate the stream discharge. The calculations are straightforward for those students with a basic understanding of geometry or the teacher can perform the calculations for younger students. It is often worthwhile to repeat the measurements several times and then take the average. Also measuring the stream discharge at different locations using the same method will help improve your confidence in your measured value.

WatershED

Boulder Creek/
St. Vrain
Watershed
Education

APPENDICES

APPENDIX A
GLOSSARY

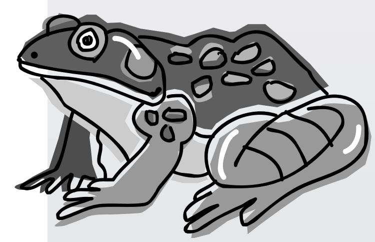
Acre foot: The amount of water that would cover one acre at the depth of one foot (325,900 gallons).

Aquatic Insect: Insect species whose larval and juvenile forms inhabit streams or lakes.

Benthic: Bottom-dwelling. Aquatic organisms that live on or in the stream bed.

Carrying Capacity: The maximum number of organisms that a particular habitat can support over the long-term. Limited by food, shelter, spawning or nesting area, rearing cover, etc.

Coagulation: The addition of coagulant particles to water to aid in removing suspended particles in the drinking water process.



Collector: Aquatic insect that feeds by gathering detritus, bacteria, etc.

Community: The plants and animals that interact in a habitat.

Cover: Overhanging or instream structures such as tree roots, undercut streambanks, boulders, or gabions that offer protection from predators or shelter from strong currents.

Current: Sometimes refers to the swiftest part of a stream flow; otherwise refers to the velocity of the flow, measured in feet or meters/seconds (ft/s, m/s).

Decomposer: A type of stream organism, such as bacterium or fungus, that processes dead organic matter.

Detritivore: Animal that feeds primarily on detritus.

Detritus: Nutritious mixture of digested and partly digested organic matter, bacteria, fungi, feces, etc.

Discharge: The amount of water flowing past a given point on a stream. Measured in cubic feet (or cubic meters) per second (cfs;cm/s).

Dissolved Oxygen: Oxygen dissolved in water. The amount depends on temperature of the water, plant photosynthesis, plant and animal respiration, and physical aeration caused by tumbling. Measured in parts per million (mg/L).

Prior Appropriation Doctrine: "First in Time, First in Right."

Ecosystem: The interacting plants, animals, and physical components (sunlight, soil, air, water) of an area.

Effluent: Waste liquid flowing into a river or lake from a house, industry, sewage treatment plant, or other source.

Erosion: Detachment of soil particles by water, wind, ice, gravity or organisms.

Evapotranspiration: Collective term for evaporation and plant transpiration, which return water vapor from the earth's surface to the atmosphere.

Fecal Coliform Bacteria: Bacteria common to the intestinal tract of mammals. Indicates biowaste from livestock or humans and may be a sign of disease-causing pathogens.

Filtration: The filtering out of particles during the purification process for drinking water.

Food Web: A community of organisms that are dependent on one another for food.

Gradient: The slope of the streambed profile.

Groundwater: Water that sinks into the ground and collects over impermeable rock. It then flows laterally toward a stream, lake, or ocean. Wells tap it for our use. Its surface is called the "water table".

Habitat: The specific environment in which an organism lives and on which it depends for food and shelter.

Hardness: The concentration of calcium or magnesium in water; affects the availability of nutrients and toxic substances to stream organisms.

Headwaters: Small streams and creeks at the uppermost end of a river system.

Hydrologic Cycle (Water Cycle): Water in its various manifestations as vapor evaporated from oceans, lakes, streams, and plants; rain and snow; snowpack or glacier; groundwater or surface runoff; and finally as streams and rivers returning to the sea.

Larva (plural: larvae): Immature insect of the type that pupates into adult form.

Limiting Factor: A condition or situation that limits size of a population (e.g., spawning or rearing habitat, food, cover, migration barrier, disease, predation).

Benthic: Bottom-dwelling insects found under rocks in creekbeds.

Meander: The tendency of moving water to form S-shaped curves (meanders).

Minimum Instream Flow: Water rights that are used to ensure enough water remains in the stream to support aquatic life.

Monitor: To track a characteristic, such as dissolved oxygen, nitrate level, or fish population, over a period of time using uniform methods to evaluate change.

Non-point Source: Diffuse, overland runoff containing pollutants. Includes runoff collected in storm drains.

Nymph: Immature form of insects such as stoneflies and mayflies that do not pupate.

Parameter: A variable quantity - such as temperature, dissolved oxygen, or fish population — that is the subject of a survey of sampling routine.

Periphyton: Plants, usually algae, attached to rocks or other instream objects.

pH: Measure of acidity. Stands for "the negative logarithm of free hydrogen ions" in water. Water of low pH is acidic; high pH is basic, or alkaline.

Point Source: A pipe that discharges effluent into a stream or other body of water.

Population: A discrete portion of a species that interbreeds. If isolated from other populations of the species for long periods of time, it may evolve into a separate race or species.

Predator: A carnivorous animal that preys on other animals.

Reach: A stream section with fairly homogenous characteristics.

Riffle: A shallow, gravelly area of streambed with swift current. Used for spawning by salmonids and other fishes. The most productive area of a stream.

Riparian Zone: The border of a stream or river above its banks; affects the stream and is affected by it.

Runoff: Precipitation that flows overland to surface creeks, streams, rivers, and lakes.

Sediment: Fine soil or mineral particles.

Side Channel: A flood channel or abandoned stream channel connected to a stream or river at periods of high flow. Serves juvenile fish as rearing habitat and refuge from floods.

Siltation: The process of becoming clogged with fine sediments.

Storm Drain: A system of gutters, pipes, or ditches used to carry stormwater runoff into sewers or streams.

Stormwater Runoff: Surface water that washed off land after a rainstorm. In developed watersheds it flows off roofs and pavements into storm drains which may feed directly into the stream; often carries concentrated pollutants.

Surface water: water that is on the Earth's surface, such as in a creek, stream, river, lake, ocean, or reservoir.

Suspended Sediments: Fine mineral or soil particles that remain suspended by the current until deposited in areas of weaker current. They create turbidity and, when deposited, can smother fish eggs or alevins. Can be measured in a laboratory as "Total Suspected Solids" (TSS).

Toxic: Poisonous, carcinogenic, or otherwise harmful to life.

Turbidity: A measure of material, usually fine sediments, suspended in water; determined by passing light through a water sample.

Urban Stream: A stream passing through urbanized area. Impacted by urban stormwater runoff; often channelized; sometimes trashed. Usually an excellent candidate for rehabilitation.

Watershed: The entire drainage area or basin feeding a stream or river. Includes surface water, groundwater, vegetation, and human structures.

Water Rights: Legally established right to appropriate water from a given stream.

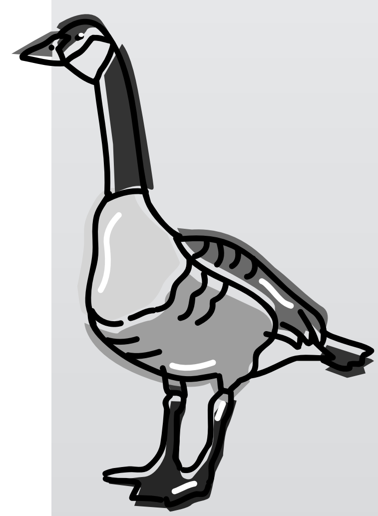
Water Table: The upper surface of the groundwater; the level below which the soil is saturated with water. Its depth is influenced by rainfall and by human development (wells, drainage ditches, loss of wetlands, etc.).

Wetlands: Habitats flooded with shallow water all or part of the year. Can be identified by unique plants which have adapted to oxygen-deficient (anaerobic) soils. Wetlands influence stream flows and water quality

APPENDIX B

Fish, Amphibians, Reptiles, Trees, Plants and Shrubs found in the Boulder Creek Watershed

Common Name	Species	Native
FISH		
rainbow trout	Oncorhynchus mykiss	no
brown trout	Salmo trutta	no
common carp	Cyprinus carpio	no
central stoneroller	Campostoma anomalum	yes
fathead minnow	Pimephales promelas	yes
longnose dace	Rhinichthys cataractae	yes
creek chub	Semotilus atromaculatus	yes
longnose sucker	Catostomus catostomus	yes
white sucker	Catostomus commersoni	yes
plains top minnow	Fundulus sciadicus	yes
western mosquito fish	Gambusia affinis	no
green sunfish	Lepomis cyanellus	yes
largemouth bass	Micropterus salmoides	no
AMPHIBIANS		
tiger salamander	Ambystoma tigrinum	yes
Western toad	Bufo boreas	yes
great plains toad	Bufo cognatus	yes
woodhouse's toad	Bufo woodhousii	yes
western chorus toad	Pseudacris triseriata	yes
bullfrog	Rana catesbeiana	no
northern leopard frog	Rana pipiens	yes
plains spadefoot frog	Spea bombifrons	yes
snapping turtle	Chelydra serpentina	yes
painted turtle	Chrysemys picta	yes
ornate box turtle	Terrapene ornata	no
REPTILES		
six-lined racerunner	Cnemidophorus sexlineatus	yes
many-lined skink	Eumeces multivirgatus	no
lesser earless lizard	Holbrookia maculata	no
short-horned lizard	Phrynosoma douglassii	yes
red-lipped plateau lizard	Sceloporus undulatus erythrocheilus	yes
racer	Coluber constrictor	yes
western rattlesnake	Crotalus viridis	yes
milk snake	Lampropeltis triangulum	yes
smooth green snake	Liochlorophis vernalis	yes
northern water snake	Nerodia sipedon	yes
bullsnake	Pituophis catenifer	yes
plains blackhead snake	Tantilla nigriceps	yes



Common Name	Species	Native
western terrestrial garter snake	Thamnophis elegans	yes
plains garter snake	Thamnophis radix	yes
common garter snake	Thmnophis sirtalis	yes
lined snake	Tropidoclonion lineatum	yes

VEGETATION

TREES

green ash	Fraxinus pennsylvanica	no
box elder	Negundo aceroides	yes
plains cottonwood	Populus deltoidea ssp. occidentalis	yes
hackberry	Celtis reticulata	yes
Russian Olive	Elaeagnus angustifolia	no
peach-leaved willow	Salix amygdaloides	yes

SHRUBS

wax currant	Ribes cereum	yes
hawthorn	Crataegus spp	yes
wild plum	Prunuts americana	yes
wild rose	Rosa arkansana	yes
salt cedar*	Tmarix ramosissima	yes
snowberry	Symphoricarpos occidentalis	yes
sandbar willow	Salix exigua	yes

HERBACEOUS PLANTS

arrowhead	Sagittaria latifolia	yes
foxtail barley	Critesion jubatum	yes
broad-leaved cat-tail	Typha latifolia	yes
prairie cord-grass	Spartina pectinata	yes
sand dropseed	Sporogbolus cryptandrus	yes
kochia	Kochia sieversiana	no
wild licorice	Glycyrrhiza lepidota	yes
poison ivy	Toxicodendron rydbergii	yes
pondweed	Potamogeton spp.	yes
saltgrass	Distichlis stricta	yes
sunflower	Helianthus nuttallii	yes
water-plantain	Alisma plantago-aquatica	yes
western wheatgrass	Pascopyrum smithii	yes
bulrush	Schoenoplectus lacustris	yes

Source: Mutel, Cornelia Fleischer and JohnC. Emerick. From Grassland to Glacier: the Natural History of Colorado and the Surrounding Region. Johnson Publishing 1992. pages 59-70.

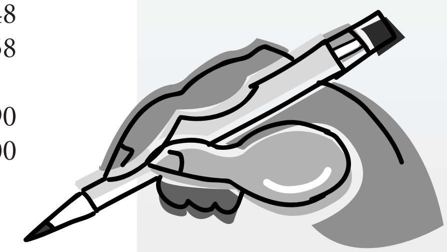
APPENDIX C

REFERENCE PEOPLE, PLACES, BOOKS AND VIDEOS

WASH COMMUNITIES

WASH Education Program 303-413-7365
Stormwater Quality Office 303-413-7350
Drinking Water Program..303-413-7400
Boulder Wastewater Treatment Plant, Superintendent 303-413-7340
Boulder Drinking Water Treatment Plant, Superintendent 303-441-3248
Open Space and Mountain Parks Education 720-564-2058

Environmental Affairs Office 303-441-3090
Boulder Public Library 303-441-3100



BVSD AND SWSD

Science Coordinator/FOSS Center 303-447-5106
Science Fair..303-447-5067 or 303-447-5087
Technology 303-447-5092
St. Vrain Valley School District Science Coordinator 303-682-7246
Longmont Drinking Water Treatment Plant 303-651-8481
Longmont Wastewater Treatment Plant 303-651-8382
Louisville Drinking Water Treatment Plant 303-335-4792
Louisville Wastewater Treatment Plant 303-335-4780
Town of Erie Water Reclaimation Plant 303-665-6933
Town of Erie Water Treatment Plant 303-926-2895
Town of Superior Town Hall..303-499-3675

Town of Niwot
Lefthand Water District – www.lefthandwater.dst.co.us 303-530-4200
Niwot Sanitation District 303-652-2525

Places to Go on Field TripsTour (5th grade and above)
Boulder Wastewater Treatment Plant, Superintendent 303-413-7340
Boulder Drinking Water Treatment Plant, Superintendent 303-441-3248
Boulder Creek Path and Fish Observatory
City of Boulder Open Space and Mountain Parks properties 720-564-2000

BOOKS

Available for checkout by calling the WASH Program at 303-413-7365.

CHILDREN'S LITERATURE (YELLOW)

Arnosky, J. (1997). *Watching Water Birds.* Washington, DC: National Geographic Society.

Provides a personal look at various species of fresh and saltwater birds, including loons and grebes, mergansers, mallards, wood ducks, Canada geese, gulls, and herons.

Bellamy, D. (1988). *Our Changing World, The River.* New York: Clarkson N. Potter.

Relates how plants and creatures co-exist in a river and their struggle for survival when a man-made catastrophe strikes.

Berry, J. (1984). *What To Do When Your Mom or Dad Says... "Turn Off the Water & Lights!"* Danbury, CT: Grolier Enterprises Corp.

Discusses why it's important to conserve our natural resources and ways to conserve and preserve those resources in your everyday life.

Bunting, E. (1996). *Secret Place.* New York: Houghton Mifflin.

A young boy finds a patch of wilderness in the city.

Butterfield, M. (1991). *Frog.* New York: Little Simon.

Follows the transformation of a frog, from frog-spawn to full-grown adult.

Cherry, L. (1992). *A River Ran Wild.* New York: Harcourt Brace Jovanovich Publishers.

An environmental history of the Nashua River, from its discovery by Indians through the pollution years of the Industrial Revolution to the ambitious cleanup that revitalized it.

Cole, J. (1986). *The Magic School Bus at the Waterworks.* New York: Scholastic.

Takes readers on a trip through the water cycle and treatment methods and also talks about water conservation.

Cole, J. (1992). The Magic School Bus on the Ocean Floor. New York: Scholastic.

On another special field trip on the magic school bus, Ms. Frizzles's class learns about the ocean and the different creatures that live there.

Cooper, A. (1996). *Above the Treeline.* Denver, CO: Denver Museum of Natural History.

Examines the lives of several different species that can be found in alpine tundra areas. Lists facts and habits of those species and discusses interdependency.

Cooper, A. (1998). *Around the Pond.* Denver, CO: Denver Museum of Natural History.

Examines the interdependent lives of the various animals and plants that inhabit various parts of a pond, from the surface film of the water to its weedy depths.

Dell'Oro, S. & Varela-Paul, A. (1999). *Sneaky Salamanders.* Minneapolis, MN: Lerner Publications.

Introduces the physical characteristics, behavior, habitat, and life cycle of salamanders.

Dewey, J. O. (1987). *At the Edge of the Pond.* Boston: Little, Brown and Company.
Explores the levels of life in a pond from the muddy shore to the murky bottom.

Doan, Dr. K. (1987). *Wilderness Album Series, FISH.* Winnipeg, Canada: Hyperion Press Limited.
Tells about common fish found in North America and lists interesting facts and figures about each.

Fleisher, P. (1999). *Webs of Life: Salt Marsh.* New York: Benchmark Books.
Describes the physical environment of a salt marsh and the plants and animals that live there.

Ganeri, A. (1992). *And Now... the Weather.* New York: Aladdin Books.
Examines the importance and causes of weather and how it can change and be predicted.

Giono, J. (1985). *The Man Who Planted Trees.* Chelsea, VT: Chelsea Green.
The story of a man's generosity to nature, a life devoted to planting trees.

Goldman-Koss, A. (1987). *Where Fish Go in Winter.* Los Angeles: Price Stern Sloan.
Brief illustrated verses provide answers to a variety of questions about nature including why snakes shed their skin and why leaves change color.

Himmelman, J. (1998). *A Salamander's Life.* Danbury, CT: Children's Press.
Illustrations and simple text follow a salamander through its life cycle, from larva in a pond through winter hibernation to spring mating.

Iverson, D. (1999). *My Favorite Tree.* Nevada City, CA: Dawn Publications.
Examines the traits and uses of twenty-six North American trees, from the ash to the yew, and describes notable or historic specimens.

Jennings, T. (1985). *The Young Scientist Investigates Pond Life.* Chicago: Childrens Press.
An introduction to the plant and animal life of ponds which includes study questions, activities, and experiments.

Liptak, K. (1991). *Saving Our Wetlands and Their Wildlife.* New York: Franklin Watts.
Describes different types of wetlands and their wildlife, including endangered plants and animals, explaining the environmental threats to the wetlands themselves.

Locker, T. (1997). *Water Dance.* New York: Harcourt Brace & Company.
Water speaks of its existence in such forms as storm clouds, mist, rainbows, and rivers. Includes factual information on the water cycle.

Parker, S. (1990). Eyewitness Books, FISH. New York: Alfred A. Knopf.
A photo essay about the natural world of fish and their importance in human life.

Peters, L. W. (1991). *Water's Way.* New York: Arcade Publishing.
Introduces the different forms that water can have, from clouds to steam to fog.

Pratt-Serafini, K. J. (2000). *Salamander Rain: A Lake and Pond Journal.* Nevada City, CA: Dawn Publications.
Illustrated field guide/treasure hunt presented in a journal format invites parents, teachers and children to explore local ponds and lakes in their neighborhoods.

Robertson, K. (1991). *Signs Along the River: Learning to Read the Natural Landscape.* Boulder, CO: Roberts Rinehart Publishers.

Through words and pictures, reinforces the interdependence of various parts of an ecosystem while teaching how to sense the presence of several common types of plants, mammals, and birds using the five senses.

Robinson, S. C. (1994). *The Rainstick: A Fable.* Guilford, CT: Globe Pequot Press.

A boy embarks on a quest to bring back the sound of rain to his West African village. Includes a discussion of how rainsticks are used today and instructions for making a rainstick.

Ross, M. E. (2000). *Fish Watching with Eugenie Clark.* Minneapolis, MN: Carolrhoda Books.

Describes the life and career of ichthyologist Eugenie Clark, who began her research observing freshwater aquarium fishes and moved on to the underwater study of sharks and other marine animals. Includes observation tips and related activities.

Ryder, J. (2001). *The Waterfall's Gift.* San Francisco, CA: Sierra Club Books for Children.

On a visit to the old north woods, a girl enjoys the many natural treasures hidden in its deepest places.

Sabin, F. (1982). *Wonders of the Pond.* Mahwah, NJ: Troll Associates.

Describes the many varieties of plants and animals that live in a pond.

Sauvain, P. (1995). *Rivers and Valleys.* Minneapolis, MN: Carolrhoda Books.

Text and illustrations, with questions and activities, provide information about rivers and such related topics as valleys, waterfalls, dams, and floods.

Schwartz, D. (1988). *The Hidden Life of the Pond.* New York: Crown Publishers.

Photographs and text introduce the animals, insects and plants in a pond.

Seixas, J. (1987). *Water: What it is, What it Does.* New York: Greenwillow Books.

A simple introduction to water, describing its properties, uses and interaction with people and the environment. Includes five basic experiments.

Silver, D. (1994). *One Small Square: Pond.* New York: Learning Triangle.

Full of fascinating facts and activities that help children to discover the wonders and complexities of a pond ecosystem.

Thompson-Hoffman, S. (1989). *Delver's Danger.* Norwalk, CT: Smithsonian Wild Heritage Collection.

A bank beaver, dwelling in the bank of the Colorado River in the Grand Canyon, enlists the cooperation of every member of the beaver clan to protect the family and the newborns from a flood.

Wheeler, J. (1990). *The Water We Drink.* Edina, MN: Abdo & Daughters.

Talks about water as a finite resource and how pollution affects people and the water they drink. Also looks at ways that we can help to conserve our water resources and limit additional pollution.

Water Pollution Control Federation (1989). *Water, the Lost Treasure: The Student Resource Guide.* Alexandria, VA: Public Education Program of WPCF.
Helps students to understand how they can conserve water, the importance of water and lists opportunities to protect water as an environmental professional.

ADULT NON-FICTION (RED)

Brower, D. (1991). *Work in Progress.* Salt Lake City, UT: Gibbs Smith.
Describes some of the big issues which have defined Brower's life's work as an environmental organizer and activist. Discusses topics from nuclear proliferation to genetic engineering.

Carson, R. (1987). *Silent Spring.* Boston: Houghton Mifflin.
A book that changed the course of history by spurring revolutionary changes in government policy toward the environment and was instrumental in launching the environmental movement.

Clarke, R. (1991). *Water, the International Crisis.* London: Earthscan Publications.
Describes the world's freshwater shortage and examines both the economics and the politics that have led to it.

Evans, H. E., & Evans, M. A. (1991). *Cache La Poudre: The Natural History of a Rocky Mountain River.* Niwot, CO: University Press of Colorado.
Explains the natural history of the river basin beginning in the tundra of Rocky Mountain National Park and tracing the river 80 miles to before joining the South Platte east of Greeley.

Fielder, J., & Pearson, M. (1993). *Colorado Rivers of the Rockies*. Englewood, CO: Westcliffe Publishers.
Raises awareness on the challenges that face the rivers in Colorado and exposes areas often overlooked in the state in favor of the mountains.

Gellhorn, J. (2002). *Song of the Alpine.* Boulder, CO: Johnson Books.
Provides a scientific sound key to understanding the subtle wonders of the alpine landscape of the Rocky Mountains, discussing plants and animals of this life zone and how they survive in the often harsh and unforgiving environment.

Gore, A. (1992). *Earth in the Balance: Ecology and the Human Spirit.* New York: Houghton Mifflin.
An argument that only a radical rethinking of our relationship with nature can save the earth's ecology for future generations.

Holbrook, S. (1956). *The Columbia.* San Francisco, CA: Comstock Editions.
A celebration of the Columbia River as a living, dominant presence in the life of a region.

Hunt, C. E. (1988). *Down by the River: The Impact of Federal Water Projects and Policies on Biological Diversity.* Washington, DC: Island Press.
Deals with rivers as whole complex ecosystems and helps explain the delicate balance between the health of streamside vegetation and the overall health of a river or stream.

Kittredge, W. (1992). *Hole in the Sky: A Memoir.* New York: Alfred A. Knopf.
The story of a pioneer family's decline and fall and an epic of American life.

Kromm, D. E. & White, S. E. (Eds.). (1992). *Groundwater Exploitation in the High Plains.* Lawrence, KS: University Press of Kansas.
An examination into the dilemmas of groundwater use in the High Plains, addressing both the technical problems and the politics of water management.

Lawrence, L. H. (1992). *Prowling Papa's Waters.* Marietta, GA: Longstreet Press.
Sheds a fresh light on America's best-known writer. A narrative of Hemmingway at his favorite pastime and of the people he gathered around him, the work he was engaged in at the time and the women in his life.

Leopold, A. (1987). *A Sand County Almanac and Sketches Here and There.* New York: Oxford University Press.
A conservation and land ethic classic that traces changes in the Wisconsin landscape month to month for a year.

Leopold, A. (1991). *The River of the Mother of God and Other Essays by Aldo Leopold* (S.L. Flader, J.B. Callicott, Ed.). Madison, WI: The University of Wisconsin Press.
A collection of essays that reveal Leopold as an activist and advocate, as well as an innovative professional, struggling with bureaucratic, political, and economic dimensions of conservation.

Leopold, A. (1991). *Round River: From the Journals of Aldo Leopold* (L.B. Leopold, Ed.). Minocqua, WI: Northword Press.
Contains some of the most telling entries Leopold made in his journals while adventuring in the wilderness. Considered a conservation classic.

Lopez, B. (1989). *Crossing Open Ground.* New York: Vintage Books.
A collection of travel essays and articles written by the author from 1978-1986.

Lopez, B. (1990). *Desert Notes: Reflection in the Eye of a Raven & River Notes: The Dance of the Herons.* New York: Avon Books.
The story of a man trying to come to terms with the Earth's landscape and with his own existence. Tells of rivers, freshwater pools, desert springs, birds, wind and rattlesnakes.

Martin, R. (1989). *A Story that Stands like a Dam: Glen Canyon and the Struggle for the Soul of the West.* New York: Henry Holt.
The story of Glen Canyon Dam and how it created the environmental movement we know today.

Muir, J. (1992). *John Muir: The Eight Wilderness Discovery Books.* Seattle: The Mountaineers.
A collection of six books written by John Muir about his life experiences and views on some of the most beautiful country in the United States.

Obee, B., & Ellis, G. (1992). *Guardians of the Whales: The Quest to Study Whales in the Wild.* Seattle: Alaska Northwest.

Scientific research papers, interviews with researchers and a look at the philosophies of observing whales are shared in this book by two whale observers.

Powell, J.W. (1961). *The Exploration of the Colorado River and its Canyons.* New York: Dover Publications.

An uncut version of J.W. Powell's exploration of the Colorado River. Includes his journal entries and his later reflections on the expedition.

Robinson, S., Nelson, D., Higgins, S., & Brody, M. (1993). *Water, a Gift of Nature: The Story Behind the Scenery.* Las Vegas, NV: KC Publications.

Talks about the history of water and why it is such an important resource not only to humans, but also for the natural world.

Rockefeller, J.D., & Albright, H. M., (1991). *Worthwhile Places* (J.E. Ernst, Ed.). New York: Fordham University Press.

A collection of letters between John D. Rockefeller Jr. and Horace M. Albright that provide insight into the planning and problem solving which led to the creation of several National Parks and other conservation /preservation efforts for areas across the United States.

Rinehart, F.R., & Webb, E.A. (Eds.). (1990). *Close to Home: Colorado's Urban Wildlife.* Boulder, CO: Roberts Rinehart.

A collection of essays and photographs that depicts the unusual but seldom appreciated wildlife of Colorado's urbanized Front Range.

Stegner, W. (1992). *Beyond the Hundredth Meridian.* New York: Penguin Books.

A recount of the successes and frustrations of John Wesley Powell, an ethnologist and geologist who explored the Colorado River, Grand Canyon and the homeland of Indian tribes of the American Southwest.

Tweit, S. J. (1990). *Pieces of Light: A Year on Colorado's Front Range.* Boulder, CO: Roberts Rinehart.

An interpretation of a year spent in Boulder and surrounding areas and its environs from a naturalist's point of view.

Wallace, D. R. (1987). *Life in the Balance.* New York: Harcourt Brace Jovanovich.

Offers a description of the state of our environment and explores the earth's ecosystems while addressing some of the nation's complex and controversial environmental problems.

Waters, F. (1985). *The Colorado.* Athens, OH: First Swallow.

A classic account of the Red River of the West, tracing the expression of the land in its history and people.

Zwinger, A. (1991). *Run, River, Run: A Naturalist's Journey Down One of the Greatest Rivers of the American West.* Tucson, AZ: University of Arizona Press.

Explores the Green River and how it relates to the landscape, how it goes, what it shows of rock and wind and how people have used it and how it has used people.

TEACHER RESOURCES (GREEN)

Agler, L. (1986). *Liquid Explorations.* Berkeley: University of California.
A resource for grades 1-3 exploring the properties of liquids through fun, fluid activities.

Atkin, J.M., Black, P., & Coffey, J. (2001). *Classroom Assessment and the National Science Education Standards.* Washington, DC: National Academy Press.
Focuses on the assessment of science based programs in the classroom with the teacher being the leading player in that assessment. Features examples, definitions, illustrative vignettes and practical suggestions to help teachers and students obtain the greatest benefit from this regular evaluation and adjustment process.

Barrett, K., & Willard, C. (1998). *Aquatic Habitats.* Berkeley: University of California.
Explains how to set up, observe, study, and reflect upon aquatic habitats that can be set up in the classroom. Conveys key biological and environmental concepts and illustrates the interactive nature of living ecosystems.

Bochinski, J. B. (1996). *The Complete Handbook of Science Fair Projects.* New York: John Wiley & Sons.
Contains hundreds of science fair project topics for grades 7 and up, and also includes 50 award-winning projects from actual science fairs.

Bonnet, R. L., & Keen, G. D. (1990). *Environmental Science: 49 Science Fair Projects.* New York: Tab Books.
Suggests forty-nine projects in environmental science, suitable for the classroom or a science fair.

Caduto, M. (1990). *Pond and Brook.* Hanover, NH: University Press of New England.
Introduces readers to the world of freshwater life with hands-on projects and activities. Investigates all common freshwater environments, from wetlands and deep lakes to streams and vernal ponds.

Daab, M. J. (1990). *Science Fair Workshop: A Step-by-Step Guide for Preparing a Research-type Science Fair Project.* Torrance, CA: Fearon Teacher Aides.
A step-by-step workbook that guides students through the process of creating a satisfying science fair project. Includes pages that can be reproduced and show students how to manage their time, set realistic goals, write hypotheses, record bibliographic information, and how to keep data tables and graphs.

Donato, W. (1998). *Rivers Curriculum Guide: Earth Science.* Carbondale, IL: Dale Seymour Publications.
One book in a series of River Curriculum Guides, which introduces lessons in geology, meteorology, cartography, and oceanography to find out about the natural and human influences on a local river or stream.

Food Works' Two Rivers Center for Sustainability (2002). *The Indoor River Book.* Montpelier, VT: Common Roots Press.
Brings the local waterways inside the classroom by explaining how to set up an indoor river which is used to create hands-on learning activities that integrates curriculum units in math, science, design technology, social studies and language and creative arts.

Fredericks, A., & Asimov, I. (1990). *The Complete Science Fair Handbook.* Glenview, IL: Good Year.
A book designed to be a reference for teachers to guide their students through the exciting and dynamic world of science. It is a systematic guide to the design and development of a successful science fair.

Hocking, C., Barber, J., & Coonrod, J. (1990). *Acid Rain.* Berkeley: University of California.
Contains activities that relate to acid rain as an environmental issue. Students gain scientific inquiry skills and improve upon reading and research skills while participating in hands-on activities.

Lal, C., & Rapp, K. A. (1996). *Improving Science Education with Community-Based Projects.* Arlington, VA: National Science Teachers Association.
An idea book that lists and describes teacher ideas and projects around the country that have successfully received funding through the Toyota TAPESTRY Awards program. Includes contact and project information by state.

LaMotte Company. (2002). *Tapwater Tour.* Chesterton, MD: LaMotte.
A hands-on test kit and mini curriculum for exploring drinking water.

Leslie, C. W., & Roth, C. E. (2000). *Keeping a Nature Journal.* North Adams, MA: Storey.
Describes fun and simple methods and techniques for writing or sketching about the world around you in order to create a journal for any weather, place or time.

National Wildlife Federation (1997). *Ranger Rick's Nature Scope: Wading into Wetlands.* New York: Learning Triangle Press.
A resource full of activities, illustrations to color and reading that will expose students K-8 to all that our quickly disappearing wetlands have to offer.

Ramig, J., Bailer, J., & Ramsey, J. (1995). *Teaching Science Process Skills.* Torrance, CA: Good Apple.
Introduces ways and activities to engage students' minds while they develop the ability to observe, infer, predict, hypothesize and investigate. Also, includes teacher notes for every activity as well as forms and guidelines for independent student lab work.

Rockwell, R. E., Sherwood, E.A., Williams, R.A., & Winnett, D.A. (1997). *The Wonders of Water.* Palo Alto, CA: Dale Seymour Publications.
Focuses on inquiry based learning as it applies to the study of water and/or liquids. Collection of experiments designed to improve upon a child's vocabulary, use of language and math skills.

Sobel, D. (1998). *Mapmaking with Children: Sense of Place Education for the Elementary Years.* Portsmouth, NH: Heinemann.
Includes hands-on projects and activities that are relevant across the curriculum and begin at the local level. Helps students to develop a sense of place scope and perspective.

Williams, Dr. R. (1998). *Rivers Curriculum Guide: Biology.* Carbondale, IL: Dale Seymour Publications.
One book in a series of River Curriculum Guides, which introduces lessons in biology in order to solve real-world environmental challenges-determining not lonely the aquatic life your local river or stream supports, but also the conditions such observations indicate.

REFERENCE (ORANGE)

CEIP Fund. (1989). The Complete Guide to Environmental Careers. Washington, DC: Island Press.
Offers career searchers an in-depth look at an expanding and increasingly important profession by presenting complete overviews of the field of work as well as examples of actual projects, jobs, and opportunities that are available.

Earth Works Group. (1989). *50 Simple Things You Can Do to Save the Earth.* Berkeley, CA: Earthworks Press.
An informative guide to the things you can do to help protect the Earth.

Gershon, D., & Gilman, R. (1992). *Household Ecoteam Workbook.* New York: Global Action Plan for the Earth.
Assists in translating a desire to do the right thing into a six-month program to help bring your household into environmental balance.

Hobbs, Justice G.J. Jr. (2003). *Citizen's Guide to Colorado Water Law.* Denver, CO: Colorado Foundation for Water Education.
The Citizen's Guide is designed to provide a comprehensive and balanced overview of Colorado water law.

Jefferson County, Colorado Planning and Zoning Department (2002). *Water Smarts: A Homeowner's Guide to Mountain Ground Water.* Colorado: Jefferson County.
A guide that provides readers with basic knowledge of mountain ground water, and an overview of your water rights and responsibilities.

McKee, T.B., Doesken, N.J., Kleist, J., & Shrier, C.J. (2000). *A History of Drought in Colorado: Lessons Learned and What's Ahead.* Fort Collins, CO: Colorado Water Resources Research Institute.
A report that describes some of the new techniques for drought monitoring that have been developed in Colorado and presents results of drought studies supported by several agencies.

Mills, E. A. (1990). *In Beaver World.* Lincoln, NE: University of Nebraska.
A history of beavers located in Rocky Mountain National Park. Describes their pacificism, vegetarianism, engineering feats, and their better-than human conservation of natural resources.

Moorhead, C. A. (1992). *Colorado's Backyard Wildlife.* Boulder, CO: Roberts Rinehart.
Introduces readers to a variety of wildlife that have adjusted to urban habitats along Colorado's Front Range. Discusses limiting factors, habitats, and behaviors of these animals, and also teaches how to identify species that may be seen in their backyard.

Moulton, T., & Pacetti, D. (1996). *Water: Colorado's Precious Resource.* Denver, CO: Metro Water Conservation.

A booklet that introduces Colorado's water history, law and vocabulary and surveys the sources and uses of water in our semiarid land. It is designed to lay a foundation for more detailed study and further action.

Mutel, C.F., & Emerick, J. C. (1992). *From Grassland to Glacier.* Boulder, CO: Johnson Books.

A guide through the natural world of the Southern Rocky Mountains including self-guided tours and easy-to-use keys to simplify the identification of communities through personal experience.

National Geographic Magazine (1993, November). *National Geographic Special Edition: Water.* p. 120.

A special edition of National Geographic devoted to the use and abuse of fresh water, our potential supply, and our prospects for the future.

Obmascik, M. (2000). *A Consumer's Guide to Drinking Water.* Denver, CO: American Water Works Association.

Answers some of the more common questions people have about their drinking water and discusses options for home filters and what you can do to protect our water quality.

Schaffner, H. (1989). *Freshwater Game Fish of North America.* New York: Gallery Books.

A comprehensive, fact-filled book provides information to find and identify popular game fish. Includes information about fish behavior and favorite eating spots, hiding spots and the best lures, tackle and bait for each fish.

Symons, Dr. J. M. (2001). *Plain Talk About Drinking Water (4th ed.).* Denver, CO: American Water Works Association.

A revised version of Symons 1994 edition, answering close to 200 questions about drinking water and related issues, such as health, home treatment, testing, conservation and federal regulation.

Symons, Dr. J. M. (1994). *Plain Talk About Drinking Water (2nd ed.).* Denver, CO: American Water Works Association.

A researched and thorough presentation of drinking water facts in order to keep water consumers informed.

Stolz, J., & Schnell, J. (Eds.). (1991). *The Wildlife Series: Trout.* Harrisburg, PA: Stackpole Books.

A reference book on North American trout which presents the anatomy and physiology, life cycle and habitat constraints, life history, origin, distribution and management of each of the thirteen species.

Manduca, C., & Mogk, D. (2000). *Digital Library for Earth System Education: A Community Plan.* Boulder, CO: University Corporation for Atmospheric Research.

A resource guide explaining what the Digital Library for Earth Systems actually is and how it can be used both inside and out of the classroom.

Wheatley-Maben, J. *Where Does Your Water Come From? The Drinking Water Source Book.* Sacramento, CA: Water Education Foundation.
Describes the water cycle, watersheds, surface water, groundwater, sources of pollution, and strategies to help prevent degradation of water supplies for children in grades 5-8.

Winter, T., Harvey, J., Franke, O.L., & Alley, W. (1999). *Ground Water and Surface Water, a Single Resource.* Denver, CO: United States Geological Survey.
An educational guide that presents an overview of the current understanding of the interaction of ground water and surface water, in terms of both quantity and quality, as applied to a variety of landscapes across the Nation.

Hunter, C. J. (1991). *Better Trout Habitat: A Guide to Stream Restoration and Management.* Washington, DC: Island Press.
A major overview of the theory and practice of modern trout-stream protection, management, and restoration.

FIELD GUIDES (PURPLE)

Conant, R., Stibbins, R., & Collins, J. (1992). *Peterson First Series Guides: Reptiles and Amphibians.* New York: Houghton Mifflin.
A field guide to the most common snakes, turtles, lizards frogs and toads, salamanders and crocodilians of North America, and tips on where to find them.

Filisky, M. (1989). Peterson First Series Guides: Fishes. New York: Houghton Mifflin.
A field guide to 220 of the most common and conspicuous fishes found in North America.

Housby, T. (1990). *The Concise Illustrated Book of Freshwater Fish.* New York: Gallery Books.
Gives concise descriptions of 40 of the major North American and European freshwater fish.

Leahy, C. (1987). *Peterson First Series Guides: Insects.* New York: Houghton Mifflin.
A field guide to 203 of the most common and conspicuous insects found in North America.

Livo, L. J. (1995). *Identification Guide to Montane Amphibians of the Southern Rocky Mountains.*

Lyons, J., & Jordan, S. (1989). *Walking the Wetlands.* New York: John Wiley & Sons.
A field guide to wetlands life in the United States that includes full-page line drawings, along with written descriptions of 100 living things, both flora and fauna.

Peterson, R. T. (1986). *Peterson First Series Guides: Birds.* New York: Houghton Mifflin.
A field guide to 188 of the most common and conspicuous birds found in North America.

Petrides, G. A. (1993). *Peterson First Series Guides: Trees.* New York: Houghton Mifflin.
A field guide to 243 of the most common and conspicuous trees found in North America.

Pobst, D. (1990). *Trout Stream Insects: An Orvis Streamside Guide.* New York: Lyons & Burford.
A field guide to some of the most important trout-stream insects with information on life cycles and behaviors.

Thompson, P. (1985). *Thompson's Guide to Freshwater Fishes.* Boston: Houghton Mifflin Company.
A field guide which includes how to identify the common fresh water fishes of North America and tells how to collect and keep them in a home aquarium. Includes range maps showing distribution of each species.

Wingate, J. L., Ph.D. (1990). *Rocky Mountain Flower Finder.* New York: Nature Study Guild.
Dichotomous key to wildflowers found below tree line in the Rocky Mountains.

SPANISH TITLES (BLUE)

S1. Jennings, T. (1988). *El Joven Investigador, El Agua.* Madrid: Oxford University Press.

S2. Jennings, T. (1990). *El Joven Investigador, Vida acuatica.* Madrid: Oxford University Press.

S3. George, J.C. (1983). *La Tierra que Habla.* Madrid: Ediciones Alfaguara, S.A.

S4. Gil, F.M. (1980). *El Rio de los Castores*. Madrid: Editorial Noguer, S. A.

S5. Vendrell, C.S., & Josep M.P. (1985). *Senses, Seasons and Elements Series, El Agua.* New York: Barron's.

VIDEOS (WHITE)

American Water Works Association. (1997). *The Adventures of Ethel Mermaid and Tad Pole: Water Treatment* [Videotape]. Denver, CO: American Water Works Association.

American Water Works Association. (1997). *The Adventures of Ethel Mermaid and Tad Pole: Fun Water Facts* [Videotape]. Denver, CO: American Water Works Association.

American Water Works Association. (1997). *The Adventures of Ethel Mermaid and Tad Pole: From Source to Tap* [Videotape]. Denver, CO: American Water Works Association.

Breeden, R.L. (Editor). (1978). *Saving Our Planet, Saving Our Land, Saving our Air and Water* [Filmstrip]. Washington, DC: National Geographic Society.

Brock R. (Executive Producer). (1987). *The Living Planet, Sweet Fresh Water* [Videotape]. Alexandria, VA: Time-Life Video.

Bureau of Land Management. *A Management Tool: Aquatic Macroinvertebrate* Sampling [Videotape]. Phoenix, AZ: Phoenix Training Center.

Bureau of Land Management. (1989). *Riparian Management and Channel Evolution* [Videotape]. Phoenix, AZ: Phoenix Training Center.

Colorado Division of Wildlife. (1992). *Water Wonders* [Videotape]. Denver, CO: Colorado Division of Wildlife.

Firrone, R. (Writer). (1987). *Tell Me Why: Fish, Shellfish, and Other Underwater Life* [Videotape]. St. Louis: Penguin Productions.

Hirschland, R.B., & Musgrave, R.L. Jr. (Managing Editors). *A World of Water: Earth's Lifeline* [Filmstrip]. Washington, DC: National Geographic Society.

LeBrun, N. (Writer). (1987). *Rocky Mountain Beaver Pond* [Videotape]. Washington, DC: National Geographic Society.

National Geographic Society. (1997). *The Power of Water* [Videotape]. Washinton, DC: National Geographic Television.

Northern Colorado Water Conservancy District & Bureau of Reclamation. (1995). *Under the Great Divide: The Colorado-Big Thompson Project* [Videotape]. Loveland, CO: Northern Colorado Conservancy District.

Oregon State University Extension Service. (1996). *We All Live Downstream* [Videotape]. Corvallis, OR: Oregon State University Agricultural Communications.

Peterson, G.A. (Editor). (1985). *The Water's Edge: Life Along the Great Rivers* [Filmstrip]. Washington, DC: National Geographic Society.

San Luis Video Productions. *Xeriscape: Appropriate Landscaping to Conserve Water.* Los Osos, CA: San Luis Video Productions.

Tom Snyder Productions. (1997). *Science Court: To Serve and Observe* [Videotape]. Watertown, MA: Tom Snyder Productions.

Trout Unlimited. (1985). *The Way of a Trout: A Conservation Classic* [Videotape]. St. Paul, MN: Leisure Time Products.

University of Wisconsin Cooperative Extension. *Educating Young People About Water: Planning for Fun and Success!* [Videotape]. Madison, WI: Distance Education/Video Production Unit.

U.S. Fish and Wildlife Service. (1987). *America's Wetlands* [Videotape]. Washington, DC.
Warriner, G. (Producer/Director). (1995). *The Art of Nature Reflections on the Grand Design* [Videotape]. Seattle, WA: Camera One.

Water Pollution Control Federation. (1989). *Saving Water: The Conservation Video* [Videotape]. Washington, DC: Interface Video Systems.

APPENDIX D
EVALUATION FORM

Deal Educator: The following survey is designed to help us determine the usefulness of the resource guide activities. We are also interested in any additional activities you develop. Please copy the form for each activity you conduct and submit it to the WASH Education Program, 4049 N. 75th Street, Boulder, CO 80301.

Date ____

Teacher Name ______________________________________

School_________________________________ Grade ______

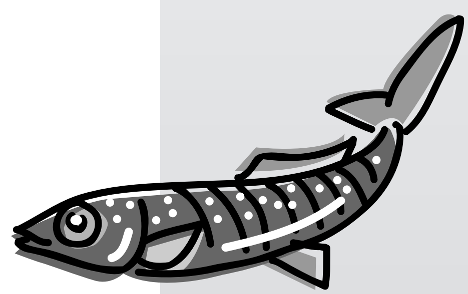
Address ____

____

Phone ____

Type of Activity ____________________________________

1. **What class was the activity used for (e.g., science, math, social studies, geography, language)?**



2. **The usefulness of this activity in accomplishing my goals was:**

   ___ excellent ___ good ___ fair ___ poor

   Explanation:

3. **The activity was:**

   ___ easy ___ appropriate ___ too difficult

   Explanation:

4. **The activity was:**

___ too advanced for my grades ___ adequate ___ too easy

Explanation:

5. **The activity:**

___ met objectives ___ did not meet objectives

Explanation:

6. **Are there subject areas or topics missing from this resource guide that should be added?**

7. **Additional Comment:**

8. **If you (or your students) create new project ideas or activities, please feel free to submit them to us for inclusion in an updated version of this resource guide.**

WATERSHED ASSESSMENT

Name ____ Date __________

Match the following words with their definitions.
Write the letter of the correct definition in the blank next to each word.

A	Insects that live in streams	____ Riparian Area
B	Large area of land that drains into a river system	____ Macroinvertebrates
C	Water from rainfall or snowmelt that runs over land	____ Xeriscape
D	Water-wise gardening	____ Runoff
E	The area of land animals use for habitat near water	____ Watershed

Read each question below and circle the letter of the correct answer.

What percent of the world's water is fresh water that people can drink?
A. More than 80%
B. About 50%
C. Almost 20%
D. Less than 1%

Where does water collected in storm drains go?
A. Directly into creeks, lakes or reservoirs
B. To wastewater treatment plants before it goes into creeks, lakes or reservoirs

Dumping used motor oil onto the ground:
A. Is a bad idea because it could pollute groundwater
B. Is a good idea because it will kill weeds

Cleaning paint off paintbrushes by rinsing them in the street:
A. Is a good idea because the paint won't clog the pipes in your house
B. Is a bad idea because the paint will go into a storm drain and into the creek and pollute the water

Homeowners use the largest amount of water for:
A. Cooking and drinking
B. Taking baths or showers
C. Washing clothes
D. Watering lawns and gardens

Riparian areas are important because:
A. 80% of our wildlife depends on them for their habitat
B. Farmers can get good fertilizer from them
C. Minnows can grow there

A good way to conserve water is to:
A. Turn off the water while you brush your teeth
B. Only water the lawn once every three days
C. Fix leaking faucets
D. All of the above.

It is important to conserve water because:
A. Every year, the Earth has 10% less water than the year before
B. There is only a limited amount of water that is good to drink
C. People need more places to go swimming

Which of the following are part of the water cycle?
A. Precipitation
B. Evaporation
C. Condensation
D. Transpiration
E. All of the above

How are water rights dispersed in Colorado?

Why is it important to clean-up streams and monitor water quality?